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ORIGINAL ARTICLES.

I.—On *Desmidopora alveolaris*, Nich., a New Genus and Species of Silurian Corals.

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(PLATE VIII.)

Desmidopora, gen. nov.

Gen. Char.—Corallum composite, with an epithecate base, the corallites subpolygonal, and indissolubly united by the coalescence of their walls. The corallites are sometimes circumscribed, but they are for the most part more or less extensively connected by deficiency of their walls in particular directions, so as to give rise to sinuous rows of serially-united tubes. The calices, like the corallites, may be circumscribed, but are mostly in the form of vermiculate grooves corresponding with the serially confluent corallites. The calices are not oblique, nor are the corallites reclined. Mural pores are numerous and well developed. Septa and septal spines are wholly wanting. The tabulæ are numerous, being simple and complete in the circumscribed corallites, but becoming vesicular in the rows of serially confluent corallites. New corallites are produced by fission.

I have found it necessary to propose the above generic name for a remarkable coral from the Wenlock Limestone of Dudley, for specimens of which I am indebted to the kindness of Mr. William Madeley, whose experienced eye had recognized that they belonged to an unusual type. In general aspect, the specimens show resemblances to the laminar forms of both *Alveolites* and *Chætetes*, as also to *Labechia*; and it was to the last of these that I was at first disposed to refer them. A microscopical examination has, however, shown that they are most nearly related in reality to *Alveolites*; the presence of numerous mural pores, quite of the type of these structures in *Favosites* itself, proving that they are indubitably referable to the group of the Favositidæ. The specimens, however, exhibit the following structural peculiarities, which preclude our referring them to any previously-named genus of Favositoid Corals with which I am acquainted:—

(1.) The primordial wall of the corallites is entirely wanting, adjoining visceral chambers being thus separated by an apparently single wall, as is the case in the genus *Chætetes*, Fischer.

(2.) A certain number of the corallites may have their visceral chambers definitely circumscribed; but others are united in serial rows by deficiency of their walls on corresponding sides. These rows are sinuous; and the calices assume, therefore, largely the form of winding labyrinthine grooves (Pl. VIII. Fig. 2).

(3.) No septa or septal spines are present. In examining the surface of well-preserved specimens one might be easily led to suppose that irregular septa were here and there developed; but these apparent septa are really only the inward projections of the walls of the corallites marking the boundaries of the separate tubes in the serially united rows.

(4.) In the completely circumscribed corallites, the tabulæ are simple, and are either horizontal or are curved with their convexities pointing towards the calices. On the other hand, in the serially united corallites the tabulæ become vesicular by reason of their confluence in adjoining tubes.

(5.) The mode of increase is by fission of the old tubes.

The characters above enumerated form, as before remarked, a combination so peculiar, as to render it impossible to refer the specimens possessing them to any recognized genus of the Favositidæ. I therefore propose for their reception the new genus *Desmidopora*. The essential distinction between this genus and all the normal genera of the Favositidæ is the fact that in *Desmidopora* the mode of growth is fissiparous, and that many of the corallites are thus confluent in serial rows. Apart, however, from this fundamental distinction, there are minor features which separate the present type from the normal genera of the Favositidæ. Thus, in *Favosites* itself there is a persistent primordial wall to the corallites, and septal spines are usually present; whereas in *Desmidopora* the walls of adjoining tubes are indistinguishably fused together, and no traces of septal structures can be detected. In *Pachypora*, Lindstr., again, not only is there a persistent primordial wall to the corallites, but each visceral chamber is contracted by the development of a special secondary lining of sclerenchyma. The genus *Alveolites*, Lam., is separated by the minor peculiarities of the oblique form of the calices and the presence of septal teeth or ridges, while the mural pores are large and uniserial. Lastly, the genus *Laceripora*, Eichw., makes a nearer approach to the present type than is the case with any other known genus of the Favositidæ. Apart, however, from the fundamental point of the fissiparous mode of increase in *Desmidopora*, the genus *Laceripora*, Eichw., is further separated from the latter by the persistent primordial wall of the corallites, the possession of distinct septa, and the fact that a special secondary lining of sclerenchyma is developed in the tubes in the peripheral region of the corallum. In tangential sections of *Laceripora* the visceral chambers of adjoining tubes often become connected by deficiency of the intervening wall; but this is not due—as might easily be imagined—to fission of the tubes. On the contrary, it is simply due to the fact that the section happens to cut at such points across the very large mural pores with which the corallites are provided.

Very closely related to *Laceripora*, Eichw., if indeed really generically distinct from it, is the genus *Somphopora*, Lindstr. ("Obersilurische Korallen von Tshau Tiën," p. 51, pl. vii. figs. 2—5); and this, therefore, also presents some resemblances to *Desmidopora*. In *Somphopora*, however, the primordial wall of the corallites is persistent, and well-developed septal structures are present, while the mural pores are of very large size, points quite sufficient to prove its distinctness from *Desmidopora*.

Beyond the limits of the Perforate Corals, the only genus with which *Desmidopora* need be compared is *Chætetes*, Fischer. In general aspect there is a decided resemblance between *Desmidopora* and some of the species of *Chætetes;* and the fissiparous mode of increase is a structural feature common to the two genera. There are, moreover, species of *Chætetes* (such as *C. Etheridgii*, Thoms. sp.) in which the corallites in the process of fission become often laterally elongated, and the calices are therefore commonly compressed and sinuous. The presence of numerous well-marked mural pores in *Desmidopora* is, however, of itself sufficient to separate the present genus wholly from *Chætetes*, Fischer.[1]

The only species of *Desmidopora* with which I am acquainted occurs in the Wenlock Limestone of Britain, and possesses the following characters :—

Desmidopora alveolaris, Nich.

Labechia alveolaris, Nich., Mon. Brit. Stromatoporoids, p. 83 (name only), 1886.

Spec. Char..—Corallum in the form of a laminar expansion, which may reach half a foot in diameter, and which varies in thickness from less than a centimetre to two centimetres. The corallum was attached to some foreign body by a peduncle, and the base is covered by a concentrically wrinkled epitheca (Pl. VIII. Fig. 1). The corallites are directed approximately at right angles to the basal epitheca, and are usually from $\frac{2}{3}$ to 1 millim. in diameter. The calices are variable in shape, but are never oblique or crescentic in form. Parts of the surface generally show many of the calices as as subpolygonal, definitely circumscribed apertures (Pl. VIII. Fig. 3); while in other parts the calices have become more or less extensively confluent, and have the form of winding and sinuous grooves (Pl. VIII. Fig. 2). The tabulæ are numerous, mostly convex, with their convexities turned upwards, and generally about half the diameter of the corallites apart. Very often they are placed at approximately the same level in adjoining tubes; and in the serial rows of corallites they become vesicular. Mural pores are numerous, but not of unusually large size.

[1] Mr. James Thomson has described mural pores as occurring in *Chætetes Etheridgii*, Thoms. sp., *C. septosus*, Flem., *C. depressus*, Flem., and *C. hyperboreus*, Nich. and Eth., jun.; and he has therefore referred these species to *Alveolites* (Proc. Phil. Soc. Glasg. 1881). I have, however, examined numerous specimens and microscopic sections of all these species, and am quite satisfied that the walls of the corallites are in all of them imperforate. Indeed, the figures given by Mr. Thomson himself show conclusively that the structures which he has described as mural pores could not possibly be of this nature.

The structure of *Desmidopora alveolaris* can be readily made out by means of thin sections, if these happen to be taken from a specimen in which the skeleton has not been much altered by mineralization. In tangential sections of such specimens (Pl. VIII. Fig. 4), the walls of the corallites are seen to be of moderate thickness, and to exhibit no traces of the primordial wall. No traces of septal structures are to be detected, and the visceral chambers of many of the corallites are directly continuous in winding series. In vertical sections (Pl. VIII. Figs. 5 and 6), the mural pores are seen at the points where the plane of the section happens to coincide with the walls of the corallites, and their presence is further recognized by the common occurrence of interruptions to the complete continuity of the walls. Where the section happens to intersect one of the rows of confluent corallites in any direction except a directly transverse one, the tabulæ are seen to be vesicular, but at other points they are as a rule complete.

In other specimens the skeleton has undergone considerable secondary change, and the appearances presented in these cases are to a large extent different to what they are in normal examples of the species. Thus, in such cases (Pl. VIII. Figs. 7 and 8), the walls of the tubes are considerably thickened, and in tangential sections exhibit a peculiar beaded appearance. The same thickening of parts of the walls of the corallites is shown in vertical sections. The first sections which I examined were taken from a specimen which had been mineralized in this peculiar way; and I was led from the phenomena which they presented to regard the species as being a peculiar form of *Labechia*, which I named *L. alveolaris*, without giving any figure or description of it (Mon. Brit. Stromatoporoids, p. 83). Such sections do, in fact, show a curious likeness to *Labechia*, and particularly to certain specimens of *L. conferta*. It need hardly be said, however, that an examination of sections of a well-preserved example of *Desmidopora alveolaris* leaves us in no doubt as to the systematic position of the species.

Formation and Locality.—Rare in the Wenlock Limestone of Dudley. I am indebted for all my specimens to the kindness of Mr. William Madeley, of Dudley.

EXPLANATION OF PLATE VIII.

FIG. 1. Under side of a broken specimen of *Desmidopora alveolaris*, Nich., of the natural size, showing the epitheca.

,, 2. Part of the surface of the same, enlarged six times. In the portion figured most of the calices are confluent.

,, 3. Another part of the surface of the same, enlarged six times. In this portion of the surface a good many of the calices are definitely circumscribed.

,, 4. Tangential section, enlarged six times. The specimen from which this was taken is but slightly altered by mineralization.

,, 5. Vertical section of the same specimen, enlarged six times.

,, 6. Part of the preceding section, enlarged twelve times, showing mural pores.

,, 7. Tangential section of a mineralized specimen, enlarged twelve times. The appearances presented in this section are not at all unlike those exhibited by some forms of *Labechia*.

,, 8. Vertical section of the preceding specimen, enlarged twelve times. Here, again, the appearances are very like those shown by vertical sections of *Labechia conferta*, Lonsd.

II.—Essays on Speculative Geology.

1.—On Homotaxis and Contemporaneity.

By R. D. Oldham, A.R.S.M.,
of the Geological Survey of India.

IN any inquiry into the history of the earth as a whole, we are met at the outset by a serious difficulty. In human affairs a general view of history, not confined to a single country, would be practically impossible, were we ignorant of the relations of the various eras from which different races reckon their dates: thus, it would be impossible to write a connected account of the history of Europe in the classical period were it not possible to determine the relation of the Olympian era to that dating from the foundation of the city of Rome. Yet the supposed case is not unlike that to which the geologist addresses himself when he endeavours to make a connected survey of such widely-separated regions as Europe, India, Australia, and America.

In the supposed case of the Greek and Roman eras, there are numerous points of contact, principally dates of battles, which, having been recorded by both nations according to their own system, enable us to compare the two, and so to determine what would be the date of any event, recorded by the one, had it been recorded by the other. But in geology we have no such points of contact; there is a very general tendency to regard any two series of beds, in which a few fossil forms specifically identical are found, as of contemporaneous origin. That this view is erroneous, and that it would be nearer the truth to say that two widely-separated beds, in which the same forms are found, could not be of *contemporaneous* origin, was long ago pointed out by Forbes and Huxley, the word *homotaxis* being invented by the latter to express the relation existing. More recently, at the Montreal meeting of the British Association, Dr. Blanford went into the question at length, and fully showed how erroneous is the assumption, often tacitly made, that similarity of included organic remains indicates contemporaneity of origin of the beds in which they are preserved.

Be it understood that I am in no way desirous of depreciating the value of palæontological evidence; but, for the purpose of what may be called historical geology, the merely approximate contemporaneity indicated by homotaxis, however perfect, is by no means sufficient. What we desire is something approaching to the accuracy of dates in written history, rather than that vague "homotaxis" indicated by the Stone or Bronze ages, with which we have to be satisfied in what is known as the Pre-Historic period of human history. As long as we are dealing only with the history of a single limited region, no serious difficulty is likely to arise; but when we try to bring the history of, say, Australia and Europe, into relation with each other, a doubt may well arise as to whether beds which would be classed as Lower Carboniferous if they occurred in Europe can be really considered as of that age when measured by European standards.

This is a question that palæontology alone can never answer

finally, and we are consequently compelled to search for some other evidence which will enable us to say, in some cases at any rate, that the beds are or are not strictly contemporaneous in their origin. One possible means would be the traces left by a period of cold similar to the well-known "Glacial period" of Post-Tertiary times. That there was such a period during which an arctic climate penetrated into temperate regions has been amply proved, and we may, I think, safely assume that this "Glacial" period of cold was contemporaneous in both hemispheres; for, whatever may have been the cause of the colder climate which prevailed during that period, it must have affected both hemispheres in the same manner at the same time.

I am not overlooking the fact that the most probable theory of the Glacial period, that of Dr. Croll, necessitates the glaciation of one hemisphere contemporaneously with the prevalence of a mild climate in the other; but if we take the Glacial period as a whole, which includes all the minor glacial and interglacial periods, we may say that the Post-Tertiary deposits which show signs of a colder climate than now prevails are of contemporaneous origin, wherever they may be found. By this I must not be understood to mean that any one particular bed in one place can be declared to be contemporaneous with a definite bed anywhere else, but that the series as a whole were of contemporaneous origin, though the actual limits may not have been the same in both cases.

If we can prove that similar Glacial epochs have occurred during the sedimentary period, using the term to denote that period of the Earth's history which is represented by the sequence of sedimentary formations, we shall have an important check on the palæontological timepiece, by which we can determine whether it is fast or slow. To prove this it will not be sufficient merely to point out that evidences of glacial action have been detected by various observers in strata of various ages, and in latitudes lower than those in which icebergs are met with at the present day; but if it can be shown that, in several widely-separated regions, and in strata which can on independent grounds be shown to be, at least, approximately homotaxial, there are to be found extensive indications of glacial action, which are not seen in the beds above or below, we may safely and fairly conclude that they all belong to a single Glacial epoch comparable to that of Post-Tertiary times.

For this purpose I shall take that Glacial period represented by the Talchir beds of India, the Ecca beds of Africa, and certain beds in Australia likewise of glacial origin. I choose this particular instance because the details are more familiar to me than any other, and moreover I shall be able to place before the readers of this Magazine some recent additions to our knowledge of the geology of these countries.

It must be well known that there have been serious differences of opinion regarding the age of the Indian and Australian Coal-measures, and that this difference has practically been between the field geologists on the one hand and the palæobotanists on the other. The former

regarded them as of Carboniferous age, or, at the latest, representing the interval between the Palæozoic and Mesozoic eras of Europe, while the latter, judging only from the plant remains found with the coal, declared it to be of Mesozoic and even of Jurassic age.

As regards the palæontological relations of these beds to each other, and to the plant-bearing series of South Africa, the subject has been so thoroughly treated by Dr. Blanford in his address that it will be needless for me to enter into a repetition of the subject. I may, however, remark that both in India and South Africa there is a series of sedimentary formations which, if identity of fossils were proof of contemporaneity, would have to be regarded as of contemporary and even coeval origin, and in both cases there are at the lower limit of the series beds whose structure proves that they must have been deposited through the agency of floating-ice. In Australia there are some beds (the Bacchus Marsh beds of Victoria) which similarly show that there must have been ice floating in large masses on the sea beneath which they were deposited: these beds have yielded a limited flora composed of three species of *Gangamopteris*, of which one is identical with and the other two closely allied to Talchir species.

Thus we see that in India, in South Africa, and in Australia there are beds whose nature indicates the existence of ice floating at or near the sea-level, in latitudes which it does not now reach, and that, as judged by the fossil plants contained in them and in the associated beds, they must be regarded as homotaxial. The conclusion is well-nigh irresistible that they all belong to a single Glacial epoch, and are consequently strictly contemporaneous in origin.

So far, I do not think any one will object to my conclusions; they have been foreshadowed by Mr. H. F. Blanford,[1] and as far as India and Australia are concerned by Dr. Feistmantel,[2] who is by no means disposed to underestimate the value of palæobotanical evidence, even where opposed to every other consideration; and so far I have been able to accept and summarize Mr. Blanford's address. But in extending the same line of reasoning, and in trying to determine even approximately the true date of this Glacial period, I shall have to enter on more disputable ground, and to refer to information acquired since Dr. Blanford's address was delivered.

The first point to notice is that the Bacchus Marsh beds of Victoria are not the only instance of Glacial boulder-beds occurring in Australia; for in New South Wales traces of Glacial action are abundant in the marine beds below the Coal-measures. I am not aware of any published record of this fact previous to my own notice of the fact[3]; but, as long ago as 1861, the lithological resemblance, as seen in a collection of specimens from New South Wales, between the marine beds of the Wollongong district and the boulder-beds of

[1] Quart. Journ. Geol. Soc. Lond. vol. xxxi. p. 519.

[2] Proc. Geol. Surv. Ind.

[3] Proc. Geol. Surv. India, vol. xix. p. 43 (1886). The substance of this paper and of another in the Journ. As. Soc. Beng. for 1884, is incorporated in the present essay.

the Talchirs, was noticed by the late Dr. T. Oldham.[1] That any special stress should have been laid on the resemblance was not to be expected, for when the words were written the Glacial origin of the Talchir boulder-bed had not been universally acknowledged, the very idea of a Glacial epoch was still strange, and no one had yet dreamed of a Palæozoic Glacial epoch, still less of using such a conception in the correlation of distant deposits. These observations appear to have dropped completely out of sight, and when I found that in Mr. W. T. Blanford's reply to Dr. Feistmantel[2] no notice was taken of this resemblance, although Mr. H. F. Blanford's suggestion that the Glacial beds of the Permian in England and the Talchirs in India were contemporaneous is quoted, I concluded that private information of later date had led to a modification of the views expressed as to the lithological resemblance of the beds.

Nevertheless, when visiting Australia in 1885, I determined to pay special attention to this point, and was not surprised, on examining the section west of Newcastle, to find that the marine beds showed abundant traces of Glacial action. Blocks of slate, quartzite and crystalline rocks, for the most part subangular, are found scattered through a matrix of fine sand or shale, which contain delicate *Fenestellæ* and bivalve shells with the valves still united, showing that they had lived, died and been tranquilly preserved where they are now found, and proving, as conclusively as the matrix in which they are preserved, that they could never have been exposed to any current of sufficient force and rapidity to transport the blocks of stone now found lying side by side with them. These included fragments of rock are of all sizes, from a few inches to several feet in diameter, the largest I saw being about four feet across in every direction as exposed in the cutting, and of unknown size in the third dimension; and I was informed by Mr. Wilkinson that in these same beds he has seen boulders of slate, etc., whose dimensions may be measured in yards.

It is impossible to account for these features except by the action of ice floating in large masses,[3] and I had the good fortune to discover, during the course of a short morning's walk, in the railway cutting near Branxton, a fragment beautifully smoothed and striated in the manner characteristic of glacier action, besides at least two others which showed the same feature, though obscurely. This seems to show that the ice was of the nature of icebergs broken off from a glacier which descended to the sea-level.

Beds of similar structure and indicating a similar mode of origin are also found at Wollongong, south of Sydney, and in the Blue Mountains. Though these have not been traced into connection with the marine beds west of Newcastle, the similarity of their position,

[1] Mem. Geol. Surv. Ind. vol. iii. p. 209 (1863).

[2] Rec. G. S. I. vol. xi. p. 148 (1878).

[3] Roughly speaking, it may be said to take 26 cubic feet of fresh-water ice floating in sea-water to float a cubic foot of granite, or 14 cubic yards to float one ton. It must be remembered that many of these fragments probably came from a distance, and that the ice was melting all the while. These figures must be reduced by two-fifths if the rock is supposed to be immersed.

fauna, and physical aspect, all leave little room for doubt that they are of the same age. Beds of similar aspect have been described by Mr. R. L. Jack, in Queensland. These beds—also of marine origin, and indicating the presence of ice floating in the sea by which they were deposited,[1] contain 22 species of fossils, so far as the fauna is known, of which 15 are also found in the marine beds of New South Wales, and only seven have not been found to the south.

As the case stands, there are in Australia two sets of beds, both of which indicate the presence of floating-ice in the water in which they were deposited. One of these, the Bacchus Marsh group, is shown by its plant fossils to be homotaxial with the Talchir group of India; the other has yielded a marine fauna of Lower Carboniferous facies, as judged by European standards, and a limited flora which, however, does not show any direct relation to that of the Bacchus Marsh beds.

I am not aware of any published attempt to correlate the Bacchus Marsh beds with a definite horizon in New South Wales before Dr. Feistmantel in 1880 gave it as his opinion that they were the equivalents of the Hawkesbury Sandstones. This opinion, so far as I can glean from his published writings, was based on the so-called Lower Mesozoic facies of the Bacchus Marsh flora, and was supposed to be confirmed by Mr. C. S. Wilkinson's discovery of glacial action in the Hawkesbury Sandstones. Mr. Wilkinson thus describes this evidence[2]—"In the sections exposed in the quarries at Fort Macquarrie, Woolloomooloo, Flagstaff Hill and other places, may be seen angular boulders of shale[3] of all sizes up to 20 feet in diameter, imbedded in the sandstone in a most confused manner, some of them standing on end as regards their stratification, and others inclined at all angles. They contain the same fossil plants that are found in the beds of shale from which they have evidently been derived. These angular boulders occur nearly always immediately above the shale-beds, and are mixed with very rounded pebbles of quartz; they are sometimes slightly curved as though they had been bent while in a semiplastic condition, and the shale-beds occasionally terminate abruptly as though broken off."

It is difficult, if not impossible, to account for these appearances, except by the action of ice in some form or other; the angular form of the fragments of shale shows that in some manner they must have been indurated before disturbance, and it is impossible to account for this induration of what must then have been recently deposited mud except by the freezing of the interstitial water. This supposition would accord with the general nature of the evidence, which indicates the action of ground-ice, such as is formed during the severe winters of North America, rather than the presence of large masses of floating-ice; and hence does not necessarily indicate so severe a climate as that afforded by the Bacchus Marsh beds of

[1] Report on the Bowen River Coal-field, by R. L. Jack, Esq., F.G.S., Brisbane, 1879.

[2] Notes on the occurrence of a remarkable boulder in the Hawkesbury Rocks, Trans. Roy. Soc. N. S. W. xiii. 105 (1884).

[3] Which is interbedded with the sandstones.

Victoria, which, according to the late Sir R. Daintree, contain "strata, mainly composed of fine mud, dotted thoughout with various-sized, generally rounded, pebbles, and those pebbles mostly unknown in the vicinity, and some not yet seen in place so far as the Geological Survey has extended a minute examination[1];" further on he says that "blocks of granite, in some instances over a ton in weight, are found imbedded in a matrix of soft mud[2];" and in the last progress report by the Secretary for Mines in Victoria, Mr. Murray states, on the authority of the late Sir R. Daintree, that some of these granite boulders resemble no granite that occurs as a rock-mass nearer than Queensland.[3]

This contrast in the nature of the evidence of glacial action shows that, if this form of argument is at all admissible, it is with the Lower Carboniferous marine, rather than with the Hawkesbury glacial beds that we must associate those of Bacchus Marsh.

Nor can palæontology be said to support Dr. Feistmantel's hypothesis; for *Gangamopteris*, the only genus of plants known from the Bacchus Marsh beds, is found neither in the plant-bearing beds, interstratified in the Lower Carboniferous marine group, nor in the Hawkesbury group. It has, however, been found in the intervening Newcastle group, and one species is identical with a Bacchus Marsh form; moreover, the only other species of *Gangamopteris* in the Newcastle beds is, according to Dr. Feistmantel, closely allied to one of the Bacchus Marsh species. This fossil evidence would by many be regarded as sufficient to prove the contemporaneity of the Bacchus Marsh and Newcastle groups; but the beds of the latter show no trace of glacial action, so that the former cannot be referred to that age in face of the existence of evidence of glacial action in the beds above and below. A reference to Dr. Blanford's address will show that whereas a very close relationship exists between the floras of the Newcastle and Lower Coal-measures, there is next to none between those of the former and the Hawkesbury Sandstones; and I may add that the stratigraphy of the beds appears to point to the same conclusion as the palæontology; so that, as the choice lies between the two, it is again rather with the Lower Carboniferous marine than with the Hawkesbury group that we must associate the Bacchus Marsh beds.

The Bacchus Marsh beds are not known to occur in conformable contact with any other group; but there is a large tract of country covered by an upper group of the same series, which is characterized by the occurrence of *Tæniopteris Daintreei*, a form which occurs in New South Wales in the beds overlying the Hawkesbury and Wianamatta groups. Owing to the large area covered by more recent lava flows, the exact relation of the two groups is unknown; but there can be little doubt that they are unconformable, for the Bacchus Marsh beds are overlapped by the *Tæniopteris* beds, which rest unconform-

[1] Geological Survey, Report on the Geology of the District of Ballan, by Richard Daintree, p. 10, Melbourne, 1866.

[2] *Ibid.*, p. 10.

[3] Geological Survey, Progress Report by the Secretary for Mines, p. 80, Melbourne, 1881.

ably on the older Palæozoics. This would imply a greater difference of age than seems to obtain between the Hawkesbury and overlying groups in New South Wales. To this I may add the difference in induration of the two, which is such that when originally surveyed, the Bacchus Marsh beds were believed to be Devonian, and are coloured on the original survey sheets as Upper Palæozoic.

As a further confirmation of the opinion ventured on, I may point to the relationship that exists between the flora of the Damudas which overlie the Talchir group in India, and that of the Newcastle beds, which occupy a similar position above the Lower Carboniferous marine group in Australia.

To begin with, both floras are marked by the predominance of the genus *Glossopteris*, which, in the Newcastle flora, comprises nine out of 26 species, or 35 per cent. of the total number of species, and 19 species out of 63, or 30 per cent. of the total number of species in the Damuda flora; of these, one species, *G. browniana*, is identical in both cases, and three Newcastle species, *G. linearis*, *G. ampla*, and *G. parallela*, are represented by the allied Damuda species, *G. angustifolia*, *G. communis*, and *G. damudica*. The genus *Phyllotheca* is represented in both floras, and the Australian form is allied to, and was long considered identical with, the *P. indica* of the Damudas. *Vertebraria* is found in both series, and is only known elsewhere from the "Jurassic" beds of Siberia. *Sphenopteris alata*, Brong., is another species represented by allied forms in the Damuda flora, and *Gangamopteris angustifolia*, M'Coy, is common to the two floras. Besides these the genus *Noeggerathiopsis* is represented in both floras, so that we have in all six genera and two species common to the two floras, besides five species represented by allied forms. In other words two-thirds of the genera and more than a quarter of the species of the Newcastle flora are represented in that of the Damudas.

Taking all these points into consideration, I think we may safely affirm that the Talchirs of India, the Ecca beds of South Africa, the Bacchus Marsh beds in Victoria, and the Marine beds below the Newcastle Coal-measures in New South Wales, were all deposited contemporaneously, and that during their deposition there prevailed a Glacial epoch comparable to, if not even more severe than, that of the Pleistocene period.

This conclusion brings out the contradictory nature of the Palæontological evidence even more strongly than it was possible for Dr. Blanford to do in his address, for it shows that the coexistence of a Jurassic flora with a Carboniferous fauna was no mere local phenomenon, but that the Jurassic flora had established itself over nearly half a hemisphere, while the Carboniferous Mollusca were still inhabiting the seas.

In the face of this contradiction, it may be allowable to doubt whether either form of palæontological evidence can be regarded as absolutely trustworthy, and to question whether the beds containing the Lower Carboniferous marine fauna may not have been deposited synchronously with the deposition of the Permian Boulder-beds of England, and with certain Boulder-beds which are known to exist

in North America at about the same horizon. It is, however, at present impracticable for me to follow up this question for want of access to books of reference; but this is of comparatively minor importance, as my purpose has merely been to show that there have been glacial epochs comparable to that of the Post-Tertiary period; and having shown that such a glacial epoch did at one time affect a large portion of the Earth's surface, it becomes easy to acknowledge that similar periods of cold have occurred before and since, and that we must not attempt to ascribe every occurrence of Glacial beds of Tertiary or Pre-Tertiary age to some merely local cause. And having acknowledged this, we at once obtain what was wanted, a check on the palæontological timepiece, a time-signal on the chronograph of the world.

Note.—A month ago I would have appealed, as proof positive of the contentions stated above, to the discovery in the Salt Range of the Punjab of marine fossils identical with those of the Australian Carboniferous beds. These are derived from beds which exhibit ample proofs of glacial action, and were on that ground assumed by Dr. Waagen to be of the same age as the Talchirs, which he agreed with most of the members of the Geological Survey in regarding as of Palæozoic age. The pebbles in which the fossils were found might in hand-specimens be taken for concretionary nodules, and an imperfect description of their mode of occurrence would support this idea; moreover the coincidence of the fauna and physical conditions with those of the Australian beds is very striking. There was every temptation for me to accept Dr. Waagen's conclusions, but a careful examination of the beds, and of the mode of occurrence of the fossils, has convinced me that this is a mere coincidence, and that the fossils, which occur as transported pebbles, can consequently be of no use in determining the homotaxis of the beds from which they are derived. The stratigraphical relations of these beds are such as to associate them with the Nummulitics; and as boulder beds, presumably of glacial origin, have been recorded by Mr. Lydekker as conformably underlying the Nummulitics of Ladák, there is no difficulty in finding a horizon to which the beds can be referred.

III.—Essays on Speculative Geology.

2.—Probable Changes of Latitude.

By R. D. Oldham, A.R.S.M. etc.

Part I.—Glacial Periods in Low Latitudes.

In my last essay I had occasion to refer to the former existence of icebergs in localities which now lie in latitudes lower than those in which glacial action is known to have reached, even during the last Glacial period. But, surprising as it may be to find evidence of glacial action within a few degrees of, and, as in the case of the Bowen River Coal-field, a few degrees within, the tropics, this sinks into insignificance in the face of the evidences of repeated Glacial periods that may be found in India, and especially in the Himalayas.

In Kashmir Mr. Lydekker has described [1] a group of beds composed of a fine-grained matrix, through which are scattered boulders of crystalline rock; these were considered to be of glacial origin, and indeed it is difficult to conceive of any other satisfactory explanation. This group, the Punjal Conglomerates, has not yet been identified with certainty in the Simla region of the Lower Himalayas; but there is a group of beds whose position and appearance render it probable that they are of the same age.

Above this group, which may represent the Punjal Conglomerates of Kashmir, but separated from them by a considerable though undetermined thickness of beds and an unconformity, comes the Blaini group,[2] which is so unique in its character, and so constant over a large area, that it is most important in unravelling the structure of the hills. It consists of a band, seldom over 30 feet thick, of thin-bedded limestone resting on a "conglomerate," the matrix being usually a fine-grained slate, through which pebbles and boulders of slate and quartzite are scattered. The aspect of the rock is decidedly glacial, and my colleague Mr. C. S. Middlemiss has discovered a pebble scratched in a manner very suggestive of ice action.

Yet higher in the series there is the Mandhâli group, which, though it has so far yielded no scratched pebble, is even more conspicuously glacial than the Blaini Conglomerate; and, yet newer, there are at the base of a quartzite series, provisionally known as the Báwars, some beds originally composed of fine sand, through which rounded fragments of quartzite sometimes over a foot in diameter are scattered; these beds are associated with a very coarse-grained arkose, itself indicative of a more severe climate than now prevails in these latitudes, even at an altitude of 15,000 feet. These last two groups have not yet been proved to be distinct; but there is no reason for doubting their distinctness, or suspecting their identity.

All these beds are conspicuously of subaqueous origin, and if we except the Báwar beds—which have so far been identified in one locality only—too widespread in their distribution and too constant in their characters to render it probable that they are of other than marine origin. There are, besides, very good reasons, which it is needless to enter on here, for supposing that all the sedimentary beds of the Lower Himalayas are of marine origin.

In the Lower Himalayas no pre-Tertiary glacial beds of later date than the Báwars have yet been determined; but in Ladak Mr. Lydekker has described a group of beds which he considers of glacial origin, as conformably underlying the Nummulitics.[3]

Leaving the Himalayas, we find in the Salt Range proofs of glacial action at more than one horizon. The newest of these is in the "Olive group," which was originally described as Cretaceous, and lately, on the strength of some *Conulariæ*, identical with species found in Australia, which were supposed to be derived from con-

[1] Memoirs Geological Survey of India, vol. xxii. p. 247.

[2] First described by Mr. H. B. Medlicott, Memoirs Geological Survey of India, vol. iii. pt. 2, p. 30.

[3] Memoirs Geological Survey of India, vol. xxii. p. 104.

cretionary nodules formed *in situ*, has been declared to be Carboniferous and contemporaneous with the Talchir group of the peninsula.[1] This last supposition may or may not be true; but, as I have already explained, there can be no manner of doubt that the fossils occur in transported pebbles, and are consequently valueless for determining the homotaxis of this group.[2]

Besides the Olive group, Mr. Wynne has described glacial boulder beds in the Speckled and Purple Sandstone groups of the Salt Range,[3] and in the Trans-Indus extension of that range glacial boulder beds[4] crop out from below a limestone of Upper Carboniferous age.

In the peninsula we know of but a single group of glacial beds, but it is not difficult to account for the difference; for, while the extra-peninsular area has yielded an extensive and fairly complete series of marine sedimentary beds, these are conspicuously absent in the peninsular area. The limestone of the Vindhyan series and the Talchir group of the Gondwanas may be of marine origin; but, apart from them, the rocks of the peninsula, where not of volcanic or metamorphic origin, are almost entirely river deposits; so that the absence of any trace of more than a single glacial period is more than possibly due to their records having been destroyed.

These facts are in themselves sufficiently striking and difficult to reconcile with some of the generally accepted hypotheses of geology, but they are emphasized by a detailed examination of two of the instances. To take the Olive group of the Salt Range, boulders and pebbles showing glacial striæ are abundant, and it is by no means unusual to find an irregular-shaped mass of hard crystalline rock with one, and occasionally more than one, of its surfaces ground into a flat facet, smoothed, polished, and striated with nearly parallel striæ.

In the case of the Talchir boulder bed of the peninsula, it has been usual to ascribe its origin to winter coast ice; but the flattened boulders of the Olive group indicate a more prolonged wearing, a greater pressure and a greater constancy of direction of motion than can be accounted for on this supposition. We are consequently driven to the hypothesis that they have been ground by a glacier which descended to the sea-level and gave off icebergs there.

Now the majority of these boulders consists of rocks of recognizably peninsular types, not a few are of a very highly siliceous felsite porphyry, which is at present only known in the Rajputana Desert, and not a single fragment has yet been found which can be declared to be derived from a Himalayan source. Besides this, the pebble band from which the *Conulariæ* referred to above were obtained exhibits certain peculiarities of distribution, which indicate that the source from which the pebbles were derived lay to the southwards.[5]

[1] Records Geological Survey of India, vol. xix. p. 22.
[2] Ibid. p. 127, *et sequel.*
[3] Memoirs Geological Survey of India, vol. xiv. pp. 87, 93, 214, etc.
[4] Ibid. vol. xvii. p. 239.
[5] Records Geological Survey of India, vol. xix. p. 129.

The boulder bed of the Olive group has not yet yielded any fossils of contemporaneous origin, but it appears to be perfectly conformable to beds of undeniably marine origin, and every argument from analogy is in favour of the supposition that it is itself either of marine or estuarine origin. But, as I have shown above, the land surface of whose waste it is composed lay to the south, so we arrive at the rather startling conclusion that when the beds of the Olive group of the Salt Range were being deposited, *there were glaciers which descended to the sea-level in a region which now lies within 34 degrees of the Equator.*

In that great and almost unknown tract lying between the Aravalli Mountains and the Indus, which is comprehensively entitled "Desert" on the maps, there may be found near the town of Pokran, in N. latitude 26° 55′, an old land-surface showing glacial groovings and striæ. These might be ascribed to the action of winter coast ice formed on the margin of a lake or sea; but, in the boulder beds which occur in the neighbourhood, and are without doubt of the same age as the glaciated land surface, there may be found facetted blocks which, like those of the Salt Range, could not be ascribed to anything but glacier action. Moreover, this land-surface is covered in places by a boulder bed with a hard intensely tough matrix, differing from the stratified boulder beds of the neighbourhood in much the same manner as the "till" of Scotland differs from the marine boulder-clays of the Midland Counties; if the hypothesis that the toughness of the former is due to its being a "Grundmoraine" be accepted, it follows that the same explanation will account for the toughness of the boulder beds of Pokran, and we have yet another proof of the existence of glaciers on this old land-surface.

The boulder beds in the Desert have been traced for sixty miles north-east of Pokran; in the vicinity of the old land-surface the boulders are almost exclusively of porphyry and syenite derived from it, but further north blocks of gneiss of the peninsular type become common; and in N. latitude 27° 30′, East longitude 72° 30′, there is a block of very coarse-grained granite, of which 10 feet × 7½ feet × 3 feet is exposed above ground. The nearest source from which this block could have been derived is in the Aravallis full 150 miles away. The age of these boulder beds appears to be the same as that of the Talchirs; the reasons for this conclusion are of a purely inferential nature, but their extent, combined with the distance from which some of the blocks have been transported, as well as their position on the western margin of the peninsular area, point to the conclusion that they are of marine origin; so that here again we have *evidence of glaciers having descended to the sea in a district now less than 27 degrees from the Equator.*

Part II.—General Considerations.

It has long been known that there were ample proofs of the former existence of mild, even subtropical climates within the Arctic circle; but the continuity of this climate, and the absence of any signs of

the extreme cold which now prevails in that region, was never ful understood till it was described and emphasized by Baron Norde skiöld. In a lecture of his published in this MAGAZINE, after revie ing the evidence of the fossil flora and fauna, he remarks on t favourable nature of the country for geological investigation, on t completeness of the series extending one may say from the Siluri to the Tertiary, and emphasizes the fact that, in all the sections had examined, he never saw a boulder "even as large as a chil head" in any rock of Tertiary age or older.[1] Various hypothes have been propounded to account for these warm climates in t Arctic regions without involving a shifting of the earth's polar axi the most ingenious and captivating of these is doubtless Mr. Wallace modification of Dr. Croll's theory, according to which the mi climates of the polar area were due to the warming effects of curren of heated water, from the equatorial regions, which have been cut by a gradual development of the continental areas. Looked at fro the polar point of view, this hypothesis was legitimate and compete enough to account for the facts it was intended to explain; but hypothesis is only acceptable as long as nothing directly incompatib with it is known, and however competent the hypothesis may be account for the mild climates of what are now the Arctic regions, is absolutely incompatible with the evidences of repeated glaciatio in low latitudes which I have referred to above.

Mathematicians forbid us to explain the circumstances by a shif ing of the axis of revolution of the earth. Whether in this they a right or wrong is immaterial, for it seems to me that there is a equally satisfactory hypothesis open to us. Mr. Fisher, in h "Physics of the Earth's Crust," has given good reasons for supposin that there is a fluid or semifluid layer intervening between the soli core and the solid crust of the earth,—in other words, that the latt has a power of shifting its position on the former; if this theory accepted, it is quite conceivable that the portion of the earth's cru which now occupies the polar circle may once have lain under t Equator and *vice versa*; indeed I find in Mr. Fisher's [2] book an asse tion of the probability of this shifting of the polar and equatoria areas based on reasons quite different from and independent of thos I have given for the same conclusion.

The known facts of stratigraphical geology, more especially th existence of regions which can be proved to have undergone com pression to the extent of two or more times their present dimension in immediate proximity to others in which the beds have suffere little or no compression, show that to some extent this shifting the crust of the earth over its core must take place, and almost th only argument that can be produced against an extension of the sam

[1] GEOL. MAG. 1875, p. 531, and 1876, p. 266. I cannot help contrasting th with my own experience in the Himalayas, where the series is well exposed numerous deep valleys, where there is an extensive series of beds extending from ev before the Silurian to the Tertiaries, and where evidences of pre-Tertiary glaci action met me, I might almost say at every turn.

[2] Physics of the Earth's Crust, p. 184. But earlier still see "On a Possible Cau of Climatal Changes," by Dr. John Evans, F.R.S., F.G.S., GEOL. MAG. 1866, 171.—EDIT.

reasoning would be derived from the doctrine of permanence of continents. It is, however, by no means inconceivable that the two hypotheses might be quite consistent; were the differences between the continental and oceanic areas entirely due to differences in the structure of the crust, the latter might shift its position relative to the core to any extent without interfering with the relative positions and forms of the continental and oceanic areas.

But is this doctrine so well established that it can be used as an argument against any hypothesis which is fairly supported by known facts? I think not. It is unnecessary to refer to the fact that the "Oceanic" island of South Georgia has been found to consist of clay-slate,[2] and not of volcanic rocks, as *ex hypothesi* it should, for there are certain peculiarities, in the palæontology of India and South Africa, which indicate the former existence of direct land communication between the two countries. This was first pointed out by Mr. H. F. Blanford, whose paper is somewhat contemptuously dismissed by Mr. Wallace with the remark that "the notion that a similarity of the productions of widely separated continents at any past epoch is only to be explained by the existence of a direct land connexion, is entirely opposed to all that we know of the wide and varying distribution of all types at different periods, and is no less opposed to what is now known of the general permanency of the great continental and oceanic areas."[2] This, however, implies a misconception of the nature of the evidence, which is far from being based merely on a "similarity of the productions" of the two countries. There are in Africa two distinct floras of different ages; one of these, that of the Beaufort beds, has a flora consisting of five distinct species, of which one is identical, two are closely allied to, forms found in the Damuda beds of India, and if we accept Dr. Feistmantel's[3] opinion, all belong to Damuda genera; associated with these plants is an extensive and peculiar reptilian fauna, of which the most prominent genus is *Dicynodon*, a genus at present unknown elsewhere except from the Panchet beds which overlie the Damudas, and another form, *Micropholis Stowei*, is a near ally of *Brachiops laticeps* from the Kamthi beds of Mangli.[4]

At a higher horizon in South Africa, in the Uitenhage formation, there is a flora consisting of 12 distinct forms, all generically different from any of the Beaufort species. Of these, one is identical with, four are closely allied to, species from the flora of the Rajmahal group in India. The difference between the flora of the Rajmahal group and of the Danudas is almost as great as in the case of the two corresponding African groups, for there are only three species in the Rajmahal flora which are in any way allied to any of the Damuda plants. We have then a close and continuous similarity between the fauna and flora of two countries lasting through a period long enough to allow of a complete specific, and almost complete generic change.

A similar but even more conclusive argument may be derived

[1] Nature, March 27, 1884, p. 509; Geol. Mag. Dec. III. Vol. I. p. 225 (1884).
[2] Island Life, p. 398.
[3] Palæontographica, 1878, p. 114.
[4] Manual of the Geology of India, vol. i. p. 123.

from the relations of the Marine Cretaceous rocks in India and o parts of the world. Both in Southern India and Southern Af there are marine deposits of Cretaceous age, with regard which Dr. W. T. Blanford writes in the Manual of the Geolog India as follows:—"Before quitting the subject of the Trichinop Cretaceous beds, it is necessary to notice the very remarkable semblance between a portion of their fauna and the species foun certain strata in Southern Africa. In the description of the Go wana system, and again in the account of the Upper Jurassic b of Cutch, the remarkable affinities between Indian fossil plants animals, and the forms found in South African beds, were repeate noticed, and there is a similar connexion between the Cretace formation in the two regions. In some deposits found resting u Karoo beds on the coast of Natal, out of 35 species of *Mollusca* *Echinodermata* collected and specifically identified, 22 are ident with forms found in the Cretaceous beds of Southern India, majority being Trichinopoly species. . . . . The South African beds are clearly coast or shallow-water depos like those of India, and the great similarity of forms certainly s gests continuity of coast-line between the two regions, and t supports the view that the land connection between South Afr and India, already shown to have probably existed in both the Lo and Upper Gondwana periods, and of which important indicati are afforded by the Marine Jurassic beds, was continued into C taceous times. It is very surprising to compare the Middle C taceous fauna of Southern India with that of the distant beds Natal, and then with the widely differing forms found in beds the same age *in Central India and Southern Arabia*."[1]

Speaking of the latter he says, "Some of the species have a w range in time among the Cretaceous rocks of Europe, but all oc in the Upper Greensand (Cenomanian), many being characteris forms, and the Cretaceous rocks of the Narbadda valley must consequence closely correspond to the Utatur group of Southe India. It is curious to note that, so far as is known, only one speci *Pecten* (*Vola*) *quinquecostatus*, is common to both, and even in t case the identification depends upon a question as to which palæo tologists are not thoroughly agreed . . .

In strange contrast with the wide difference between the kno fauna of the Bagh beds and that of the Southern India depos is the similarity between the fossil remains of the Narbad valley and those found in two localities on the south-east co of Arabia. The collections examined from both localities are sma and were obtained in each case during a short visit; but althou the united Arabian collections only comprise 13 species and t Bagh 12, three of these . . . . are common to the two countri The Cretaceous beds of the lower Narbadda valley are abo 750 miles distant from those of Southern India, and twice as f from the Arabian localities. The marked contrast between t fossil faunas in the one case, and the similarity in the othe

[1] *Loc. cit.* p 292.

tend to suggest the probability that a land barrier interposed in Middle Cretaceous times between Southern India with Assam and Arakan on the one side and the Western Narbada region with the south coast of Arabia on the other. We have thus another argument presented to us in favour of the Indian peninsula being portion of an ancient land-area; and taking into consideration the marked connexion between the faunas of the South Indian and South African Cretaceous deposits, and the circumstance that both appear to be of littoral origin, it is probable that this land-area extended to Africa." [1]

These facts indicate that the permanence of continents is a hobby which some of its admirers have ridden too hard, and at any rate prove that it cannot be used to stifle a plausible hypothesis.

Another group of facts which are in favour of the suggestion I have made above is the observational evidence in favour of a change of latitude in some of the principal European observatories. In the American Journal of Science for March, 1885, Professor Asaph Hall gives, on the authority of S. Fergola, the following table of latitudes of the principal observatories of Europe and America:—

Washington	1845	38° 53′	39″·25
do.	1863		38″·78
Paris	1825	48° 50′	13″· 0
do.	1853		11″· 2
Milan	1811	45° 27′	60″· 7
do.	1871		59″·19
Rome	1810	41° 53	54″·26
do.	1866		54″·09
Naples	1820	40° 51′	46″·63
do.	1871		45″·41
Königsberg	1820	54° 42′	50″·71
do.	1843		50″·56
Greenwich	1838	51° 28′	38″·43
do.	1845		38″·17
do.	1856		37″·92

Besides this there are the Pulkowa observations which give the following results:—

Pulkowa	1843	59° 46′	18″·73 ± 0″·013
do.	1866		18″·65 ± 0″·014
do.	1872		18″·50 ± 0″·014

I am aware that the most recent investigations of the Greenwich observations by the present Astronomer-Royal have shown that there is no proof of continuous change of latitude; but it is surely something more than a coincidence that the change in every case is in the same direction; had the change been due merely to imperfect observation or the vagaries of refraction, it would hardly have exhibited these strange coincidences. There is, however, more than one way of explaining these slight variations of latitude, and, seeing that the observations extend over a comparatively short period of time, it would not do to attach too great importance to them in this connexion.

A more important argument is to be derived from the careful measurements of the pyramids of Gizeh which have been made by

[1] *Loc. cit.* p. 297.

Mr. Flinders Petrie. The orientations of the sides and passage
the great and second pyramids vary not more than 30″ from e
other, but they both agree in varying rather than 5′ west of nort
it is inconceivable that this close approximation of the orientatio
the sides and passages of these pyramids should be due to accid
nor is it conceivable that the builders would deliberately h
introduced a variation of some 5′ west of north. A far more p
bable explanation is that owing to a shifting of the earth's crust
its core, or of the axis of revolution, there has been a variatio
that amount in the direction true north since the pyramids were bu

Such, briefly stated, are the conditions of the problem. We h
first a group of facts inexplicable, unless we grant the possibility
a shifting of the earth's crust on its core, or of the axis of revolut
of the earth; secondly a group of facts inconsistent with the o
hypothesis that could be urged against the first supposition, a
thirdly a group of facts directly confirmatory of the latter.

In conclusion I must apologize for any injustice I may have—
intentionally — committed; an official geologist in India has
contend with many difficulties, not the least of which is the impo
bility of keeping abreast of current literature, and a want of leis
for pursuing independent investigations. It had been my intent
to work out this problem more thoroughly during the current ye
but having been deputed to accompany an embassy to Tibet,
opportunity is gone, and not likely to recur for some years. I
consequently induced to put my notes on the subject together, so
what hastily I confess, as it has been my good fortune to meet w
a number of facts which cannot be ignored in any discussion of
problem of geological climates, many of them having either ne
been published at all, or only in a form not generally accessible
European geologists.

IV.—On the Tunnel Section near Honiton, Devon.

By the Rev. W. Downes, B.A., F.G.S.

THE writer has for some time hesitated to seek in the pages of
Geological Magazine a publication of his experiences up
the above subject. He fell last year into a grievous mistake wi
regard to it, and suffered that mistake to be published in
"Transactions of the Devonshire Association for the Promotion
Science, Literature, and Art." It will be his duty, when the opp
tunity comes round (as shortly it will), to call attention to th
mistake in the pages of the same periodical. In the meantime
thinks that the subject, and even the mistake associated with it, m
be of something more than local interest. At least the recantation
a published error cannot be too widely circulated.

The tunnel on the L. & S. W. Railway about a mile east of t
town of Honiton pierces a hill in a E. and W. direction. The cu
ting on the W. of the tunnel exposes the Red Marl of the Tri
That on the E. of the tunnel exposes some black or grey beds, most

[1] The Pyramids and Temples of Gizeh, by W. M. Flinders Petrie, p. 1
(London, 1883.)

arenaceous, which are now to be discussed. Both the Red Marl and the dark-coloured arenaceous beds above them have the same easterly dip of about 5°.

About a mile to the eastward of the tunnel is a north and south fault, and the tunnel beds are on the downthrow side of it.

Mr. H. B. Woodward and Mr. Ussher had in the work "Geology of England and Wales," p. 237, by the former, expressed an opinion that the beds E. of the tunnel were Gault, and the present writer approached the subject with a decided predisposition in favour of that view. He did not perhaps attach the weight to their opinion that he ought to have done, for he had somehow arrived at the impression that their opinion was but a conjecture, and did not profess to be more. Nevertheless, he would have much hesitated to call it in question, were it not that a piece of entirely new evidence was presented to him.

In the course of correspondence with the railway officials, he was informed that at the Engineer's office of the Railway Company there was a detailed diagram of the tunnel on a large scale. He went to see it, and was brought face to face with a dilemma. Either the black beds were Rhætic, or the diagram was wrong.

Could the latter be wrong? The unknown engineer who constructed it had had exceptional facilities for accuracy. Shafts had been sunk at frequent intervals, and the position, thickness, character, and colour of every bed was given with great exactness. Many thousands of pounds had depended upon the general accuracy of the section, and though the uppermost beds did not affect the tunnelling, it was but reasonable to suppose that they also would be correctly given. And in them was represented an unconformity exactly like that which exists between the Trias and the Greensand in all the country round about, the Trias (or Rhætic) dipping eastward, the Greensand above it being horizontal.

A great unconformity in the midst of the Cretaceous series was not to be thought of. If then the diagram was right, the lower beds could be nothing else but Rhætic. And such the present writer considered them to be until, after a persevering search for fossil evidence, he at last found it; but lo! *the fossils were Cretaceous!*

They were:—

Inoceramus concentricus (Park.) (abundant).	*Mytilus.*
Tornatella (*Actæon*) *affinis* (Sow.)	*Tellina.*
Pecten quadricostatus (Sow.)	*Exogyra.*
Modiola.	*Pectunculus.*

The above occurred in a black marly clay bed about six feet thick, which comes in the middle of the series.

The diagram, which—tested by the exposed beds at the base—must be accurate in the main, is certainly inaccurate as regards the uppermost beds. As before remarked, they did not affect the tunnelling, and were perhaps carelessly added. Perhaps the designer was in part inspired by the analogy of the surrounding country, with whose geology he was presumably to some extent acquainted. But as his very name is unknown, and he cannot answer for himself, it is useless to discuss his responsibility for the error.

But independently of the diagram, there was a certain balance of other improbabilities which had to be weighed. It was improbable, as urged by Mr. Ussher, that the Rhætic beds should attain so great a thickness,—about 160 feet. It was improbable, as urged by Mr. H. B. Woodward, that they should locally assume an arenaceous character (though, as already mentioned, the beds in question are not arenaceous throughout). But on the other hand, it was improbable that the marked unconformity, usual between the Trias and the Greensand, should be absent in this one spot, that the Trias should have in this particular spot no proper dip whatever, but should acquire just about its normal dip abnormally through the downthrow of a fault, and should exactly share that dip with Cretaceous beds above it.

Again, it was antecedently most improbable that Gault-like rock should reappear in this locality. At Lyme Regis, 25 miles to the S.E., black marl with *Lima parallela* occurs, but this appears to be approaching extinction westward, and is there only about 20 ft. thick. At Uplyme, Trinity Hill, Shute Hill, and Dalwood Down, eminences in a straight line from Lyme Regis to Honiton Tunnel, along the line of dip no Gault is found. And we seek for it equally in vain along the line of strike. Yet at Honiton tunnel something of the nature of Gault is found.

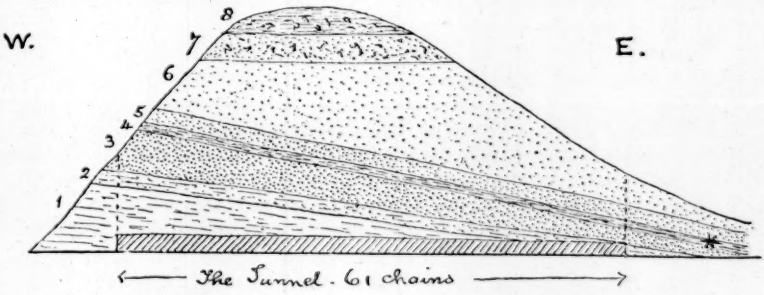
It would seem that to connect these Honiton beds with the Lyme Regis bed, a curved line must be drawn southwards and passing out to sea. Traces of dark grey beds,—all however arenaceous—are seen in the cliff-section at Whitecliff and at Seaton. Further out to sea there might once have been an areno-argillaceous bed connecting the 20 ft. bed of Lyme Regis with the 6 ft. bed of like character at Honiton. It is a conjecture with at least some probability about it.

But when we compare these so-called Gault beds of the West with the typical Gault of Folkestone (Quantum mutatus ab illo!), what have they in common? The argillaceous character has been almost entirely supplanted by an arenaceous one. The fauna has undergone many modifications. *Lima parallela* still lingers on in the attenuated bed at Lyme Regis, but has not yet been found at Honiton, where the semi-argillaceous bed is still more attenuated. Even the colour gets washed out as we go westward. Clay merges into sand. Black merges into yellow. In a word, between Upper Greensand and Gault boundary there is none in the West of England.

With the exception of the unconformity represented in the upper beds of the section, the diagram in the possession of the L. & S. W. Railway is no doubt mainly correct. It gives the following thicknesses to the several beds:—

Clay with Chert passing into Cherty Greensand, bedded ...	55 feet.
Grey Sand	81 ,,
Yellow Sand	18 ,,
Varigated Marly Clay	6 ,,
Black Sand	44 ,,
White Sand	1 ,,
Greenish Sandy Clay	10 ,,
	215 ft.
Red Marl.	

There are thus shown to be 215 feet of beds of various kinds above the Red Marl, but it is difficult in the absence of unconformity to say where the Trias ends. Probably the 10 ft. of "greenish sandy clay" belongs to the Trias. Similar beds occur in the same position in the same locality. The geological age of the "white sand" and the "black sand" is "not proven," but probably they are Cretaceous, though there is no visible unconformity to show it. The "variegated marly clay" is certainly Cretaceous, as proved by the fossils quoted above.



1. Red Marl.
2. Greenish Sandy Clay.
3. Black Sand.
4. Dark grey marl and black clay.
5. Yellow Sand.
6. Grey Sand.
7. Cherty Greensand.
8. Clay, with chert.

* The place where the fossils were found.

V.—On the Application of the term Neocomian.

By A. J. Jukes-Browne, B.A., F.G.S.

MUCH confusion and difference of opinion appears to exist with regard to the classification and nomenclature of the strata which form the lower part of the Cretaceous system, and the chief element of this uncertainty and confusion is the misconception which prevails respecting the proper signification and application of the term Neocomian. The object of the present paper is to explain the continental usage of this name, and by showing its inapplicability to any of our English strata, to prepare the way for a more satisfactory grouping of our Cretaceous rocks.

For many years English geologists were content with the nomenclature employed by the earlier students of the Cretaceous system—Webster, Murchison, Mantell and Fitton. In 1864, however, the French term Neocomian was introduced by Prof. Judd,[1] who adopted it for the Cretaceous portion of the Speeton Clay, and Sir Charles Lyell subsequently used it as a synonym for the whole Lower Cretaceous series in England as distinct from the Upper Cretaceous series or the beds lying above the Lower Greensand. Consequently in many text-books we find the following arrangement of the Cretaceous groups:—

[1] Quart. Journ. Geol. Soc. vol. xxiv. p. 218.

	Southern Area.	*Northern Area.*
Upper Cretaceous.	Chalk	White Chalk.
	Upper Greensand	Red Chalk.
	Gault	
Neocomian or Lower Cretaceous	Lower Greensand	Upper Neocomian.
		Middle Neocomian.
	Wealden	Lower Neocomian.

Now in order to ascertain whether this use of the name Neocomian was in any way desirable or justifiable, it is necessary to make some inquiry into the history of the name and its usual acceptation by the majority of geologists on the continent.

The primary groups or divisions of the Lower Cretaceous series usually recognized in France and Switzerland are those proposed by D'Orbigny, namely:—(1) *Neocomien*; (2) *Urgonien*; and (3) *Aptien*, and the history of these names is as follows. Previous to 1835 the rocks included in the first two groups were known as the "Jura-Cretacée" group, and in that year Thurman proposed to call them Neocomien, from their development in the neighbourhood of Neuchatel; this name was adopted by Marcou and others, but it is important to remember that this Neocomien series did not include the beds now known as Aptien; thus we find Prof. Marcou in his "Lettres sur les roches du Jura" writing in 1856 of Lower, Middle, and Upper Neocomien, but the summit of his Upper stage is the white limestone of Neuchatel (Urgonien).

Meantime D'Orbigny had been making his palæontological investigations, and had in 1843 described a series of beds lying between the Gault and what was then called "Neocomian" in the south-east of France; these beds he proposed to call *Aptien* from Apt in Vaucluse. The relation of the Neocomian as understood by Thurman and Marcou to the Aptien and Lower Greensand is clearly stated by Marcou in his first letter on the rocks of the Jura (p. 14) thus, "It is clear in fact that the Lower Greensand of England is in no way the equivalent of the Neocomian, and is hardly perhaps to be correlated with the upper part of the Neocomian . . . The blue marls which I have called the Marnes d'Hauterive, and which contain so many fossils, the Calcaire jaune inferieur, etc., that is to say, the Lower and Middle Neocomian, have no marine representatives in England."

He appends a table showing that these Neocomian strata are the marine representatives of the English Wealden, with possibly the lowest beds of the Lower Greensand, and he recommends the adoption of the name as indicating the normal marine type to which the freshwater Wealden is an exception.

Marcou, however, does not look with favour upon D'Orbigny's name of *Urgonien*, which was proposed in 1850, D'Orbigny then suggesting a new classification for the whole series, separating the upper half of the beds called Neocomian by Marcou under the name of *Urgonien* (from Orgon, Bouches des Rhone), and thus limiting the name Neocomian to the lower half of Marcou's series, that is, from the horizon of the yellow stone of Neuchatel downwards.

Lastly, in 1854, Prof. Renevier, of Lausanne, described certain beds, which had previously been called Lower Aptien, as a separate subdivision under the name of Rhodanien, and in 1856 he published a brief note "On some points in the Geology of England," in which he announced the results of a visit he had made to England for the purpose of comparing the Swiss and English beds. The results are that the Lower Greensand is not the equivalent of the Neocomian, but corresponds exactly with the Aptien, and that the fauna of the Atherfield beds of the Isle of Wight has the strongest analogy with that of these Lower Aptien or Rhodanien beds. Marcou, writing in 1858, says that he willingly adopts these conclusions and opinions of M. Renevier.[1]

Meanwhile, a further modification had been proposed by MM. Coquand and Leymerie, who found a difficulty in separating the Urgonien and Aptien groups in the Pyrenean district, where according to their account the rocks contain a mixture of the fossils which elsewhere occur in the Urgonien and Aptien; they therefore proposed to combine these two groups, calling the division thus formed the Urgo-Aptien, and admitting a Neocomian division below. This suggestion has been adopted by Prof. Renevier, who published the following arrangement in 1874 (Tableau des Terrains Sedimentaires):

Urgo-Aptien	Aptien Rhodanien Urgonien.
Neocomien	Hauterivien Valanginien.

The facts upon which this scheme is founded require confirmation, and the nomenclature proposed does not seem to have found much favour, D'Orbigny's names being still generally employed by French geologists.

Having now explained the origin of this nomenclature, I proceed to give the succession of the strata in question at some of the typical localities.

The most complete sections are to be found in the S.E. of France (Departments of Vaucluse, Drome and Isere), where the succession is as follows, according to MM. Cornuel and Lory.

Aptien.	Greenish sandstones. Marls with *Belemnites semicanalicutus*, *Ammonites nisus*, *Martini* and *fissicostatus*. Marls with *Orbitolites* and other fossils.
Urgonien.	Limestone with *Caprotina* (Requienia) *Lonsdalei*. Marls with *Orbitolites* and *Heteraster oblongus*. Limestone with *Caprotina* (Requienia) *ammonia*.
Neocomien.	Marls with *Toxaster complanatus*. Marly limestones with *Ancyloceras Duvalii*. Glauconitic limestones with *Bel. dilatatus*. Red limestone with *Ostrea Couloni* and *Pygurus rostratus*. Limestone of Fontanil. Marls with *Bel. latus* and *Am. neocomiensis*. Argillaceous limestones with *Am. astierianus*. Limestones with *Terebratula diphyoides*.

[1] Sur le Neocomien dans le Jura, Zurich, 1858, p. 63.

The basement beds are only found at and south of Chambery, while north of that place the Calcaire de Fontanil is the lowest bed, resting on Coral Rag. M. Lory remarks that all the limestones thicken northward toward Savoy and the Jura, while the marls increase to the southward, and Prof. Hébert [1] states that the argillaceous hydraulic limestones with *Ammonites Astierianus* attain a thickness of 500 mètres (1600 feet) near Chambery, the aggregate of the rest of the Neocomian above these limestones having an equal thickness, so that the total depth of this division here is at least 3300 feet. There is some doubt whether the lithographic limestones with *Ter. diphya* (*janitor*), which underlie those with *T. diphyoides*, should not also be classed as Neocomian. Renevier refers them to the Portlandian, but Hébert places them in the Neocomian (thickness 350 feet). Near Grenoble the Urgonien is said to be 900 mètres (nearly 3000 feet) thick, but nowhere else does it reach more than 1300 feet. The Aptien is about 60 feet thick at Grenoble, but at Bedoule it is as much as 650 feet, and in the Gard about 300 feet.[2] At Perte du Rhone, farther north, the section is given as follows by Prof. Renevier :—

Greensand with *Ammonites mammillaris*.

Aptien, 20 feet.	Hard greenish sandstone, with *Plicatula placunea* and *Am. Cornuelianus*. Sands without fossils. Greenish sandstone with *Ostrea aquila*.
Rhodanien, 56 feet.	Marly sandstones including a thin layer full of *Orbitolites lenticulata* (33 feet). Clays without fossils (10 feet). Marls with *Heteraster oblongus*, *Trigoniæ* and *Aporrhais Robinaldina*, etc. Red Limestone with *Heteraster oblongus*, *Pterocera pelagi*, and *Caprotina Lonsdalei*.
Urgonien, 340 feet.	White friable limestones and grey compact limestones in alternating beds, and containing *Caprotina* (*Requienia*) *ammonia* : base not seen.

By Pictet and Campiche the beds are differently grouped; they place the red limestone in the Urgonien, and class the overlying marls and clays as Lower Aptien, the Upper Aptien here being very thin. Sandy limestones with fossils of true Neocomian species occur at a lower horizon, the above section only extending as far as the confluence of the Rhone and Valserine.

In the Jura and near Neuchatel the succession is given as follows, the thicknesses of the lower beds being those given by Marcou :—

Aptien and Rhodanien.	Greensands of Presta with *Plicatula placunea*. Yellow marl with *Heteraster oblongus* and *Orbitolites*.
Urgonien, 150 feet.	White limestone with *Requienia ammonia*. Yellow limestone with *Goniopygus peltatus*.
Neocomien, 250 feet.	Yellow stone of Neuchatel. Marls of Hauterive with *Am. radiatus*. Limonite de Metabief with *Pygurus rostratus*. Limestone of Auberson with *Toxaster Campichei*.

[1] Bull. Soc. Geol. de France, ser. 2, vol. 28, p. 142.
[2] For this and other information I am indebted to Dr. Ch. Barrois.

The two lowest Neocomian groups have been termed by some *Valenginien* and the two upper *Hauterivien;* the lowest rests on beds of Purbeck age, containing *Planorbis Loryi*, and other freshwater shells.

Dr. Barrois informs me that the total thickness of the three divisions in the Jura is from 200 to 300 mètres (650 to 990 feet).

In the north of France there is only one locality where anything like a complete section of the series is found, and this is at Vassy in the north-eastern department of Haute-Marne. The succession here as described by M. Cornuel is as follows :—

Greensand with *Ostrea arduennensis* (? base of Gault), 28 feet.

Aptien. 97 feet.	Sand and Sandstone with *Ostrea aquila* and *O. arduennensis*.
	Plicatula clays—in three divisions, the middle containing *Ammonites nisus* and *fissicostatus*, the lower *Ostrea aquila* and *Ter. sella*, besides *Plicatula placunea*.
	Red marl with *Orbitolites lenticulata*, *Heteraster oblongus* and other fossils.
Urgonien, 118 feet.	Oolitic ironstone and ferruginous sandstone, with *Unio* and freshwater fossils.
	Mottled clays and sands (freshwater).
	Clay with *Ostrea Leymerii*.
Neocomien, 34 feet.	Yellow marly clay.
	Spatangus limestone (*Toxaster*, etc.)
	White sand.
	Ferruginous sands and ironstone.
	Dark marly clay.

Prof. Hébert prefers to group the Oyster-clay as Neocomien, and to place the red marl at the top of the Urgonien, commencing the Aptien with the Plicatula-clays.

In passing westward from the Haute Marne, the Neocomien and Urgonien beds appear to thin out, and are overlapped by the Aptien, which in Ardennes is reduced to a few feet of glauconitic clay with marly ironstone at the base containing fossils and pebbles derived from Palæozoic rocks like the "pebble beds" of Godalming and Faringdon (Barrois, Terr. Cret. des Ardennes, pp. 252, 263).

It is interesting to notice that in the Vassy section the marine Neocomian beds are succeeded by a group the greater part of which consists of freshwater beds resembling our Wealden strata. Moreover, the fauna of the overlying red bed has been identified by Renevier as that of his Rhodanien, and he finds the same fossils in the Atherfield beds of the Isle of Wight; here therefore we seem to have a basis of correlation, and it becomes important to decide whether this Rhodanien horizon should be grouped with the Urgonien or the Aptien, for it is nowhere of sufficient stratigraphical importance to rank as a separate primary division.

Two of the best modern authorities on the Cretaceous rocks of France, namely, Prof. Hébert and Dr. Ch. Barrois, agree in placing the "couche rouge de Vassy" in the Urgonien, but the difference of opinion which exists on this point may be held to prove that the Rhodanien is really a passage group, and that no very decided line can be drawn between the Aptien and Urgonien divisions of the continental series.

It is now time to examine the succession exhibited in our southern counties, where, as is well known, the series consists of a thick mass of freshwater strata (Wealden beds), overlain by marine clays and sands which are known under the name of Lower Greensand. These marine beds are everywhere divisible into three stages, the fossils of which are to a certain degree different. In the Wealden area there are :—

3. Folkestone and Sandgate beds, with *Rhynchonella Gibbsii, Rh. sulcata, Thetis Sowerbyi, Corbula elegans*, etc. (150 feet).

2. Hythe beds, with *Plicatula placunea, Exogyra sinuata, Ammonites Martini, Am. furcatus, Ancyloceras gigas, A. Hillsii* (200 feet).

1. Atherfield Clay, with *Trigonia caudata, Tr. dædalea, Perna Mulleti, Holocystis elegans*, etc. (90 feet).

In the Isle of Wight the corresponding series is very much thicker, but may be divided as below :—

3. Shanklin Sand, sands and clays down to the sand with ferruginous concretions (256 feet).

2. Walpen Sands and Crioceras beds, with *Am. Martini, Ancyloceras gigas, An. Hillsii, Exogyra sinuata*, and *Ter. sella* (400 feet).

1. Atherfield Beds, with *Trigonia caudata, T. dædalea, Perna Mulleti, Corbis corrugata*, and *Aporrhais Robinaldina* (150 feet).

Now as the Atherfield Clay is certainly not older than the Rhodanien of Renevier, there can be little doubt that the two higher groups form an expanded equivalent of the French and Swiss Aptien. The Urgonian facies of the Atherfield fauna was recognized long ago by M. Cornuel, but he remarks in 1874 that "no clear separation between the Neocomien (*i.e.* Urgonien) and Aptien can be traced in the Isle of Wight, on account of the mixed assemblage that occurs in the Crackers, which form a passage from one to the other."[1] It is evident therefore that here, as in the south of France, there is a complete passage between the representatives of the Urgonien and the Aptien.

It is only necessary to add that the lower marine beds have a limited extension, and that the uppermost beds (Shanklin sands) overlap them and spread northward over the Jurassic rocks, all the so-called Lower Greensand of our midland counties belonging to this group, the range of which is probably continuous beneath the Gault as far as Norfolk, where they pass into the upper beds of the northern Cretaceous area.

In Lincolnshire and Yorkshire beds older than the Aptien once more make their appearance, and in this area we appear to have a much more complete marine series than that of the southern counties. The Yorkshire succession has been well described by Prof. Judd some twenty years ago, and descriptions of the Lincolnshire beds will shortly appear in the Memoirs of the Geological Survey. The grouping adopted by Prof. Judd, however, does not appear to be entirely satisfactory, and his correlations with Neocomien, Urgonien, and Aptien have not been accepted by French authorities, so that I

[1] Bull. Soc. Geol. de France, 1874, p. 390.

feel justified in subjecting them to some slight criticism. First, therefore, as to the grouping of the zones; there does not seem any very good reason why the zone of *Ammonites speetonensis* should be classed with the lower zones rather than with the middle group. Prof. Judd identified twenty-six species from this zone, and of these only eight occur in the zone of *Am. noricus*, while thirteen species (50 per cent.) range up into the *Pecten cinctus* beds: again in Lincolnshire the only determinable Ammonites obtained from the clays overlying the Tealby ironstones with *Pecten cinctus* were the varieties of *Am. speetonensis* (*concinnus* and *venustus*). I am inclined, therefore, to think that a part at any rate of Prof. Judd's *speetonensis* zone should be grouped with his Middle division rather than with the Lower. The *noricus* zone does not appear to have any equivalent in Lincolnshire, and it is quite possible that the masses of clay which form the *noricus* and *speetonensis* zones in Yorkshire did not extend into Lincolnshire, no contemporaneous deposits being formed in the latter area.

In the next place it does not appear to me so very clear that the fauna of the Upper division has a closer analogy with that of the Atherfield Clay than that of the Middle division has. There is no very marked correspondence between any part of the northern and southern series, the areas in which they were deposited were evidently to a great extent separated from one another, many species common in the one area do not occur in the other, and the time range of some of those species which do occur in both series appears to be different, thus *Perna Mulleti* is abundant in the Atherfield Clay of the south, while in Yorkshire it is only quoted from the Upper division. It occurs, however, in the middle clays of Donington in Lincolnshire, and it is these clays both in Yorkshire that I am inclined to regard as the homotaxial equivalents of the Atherfield Beds, the abundance of *Meyeria* (though the species are different) and of *Exogyra sinuata* are features in common.

If these views be accepted, the Yorkshire and Lincolnshire series can be brought into greater harmony, and both may be correlated with the southern type as follows:—

	Yorkshire.	*Lincolnshire.*	*Isle of Wight.*
150 feet	Clays without fossils Cement beds	Carstone ? absent ?	Shanklin Sands.
250 feet	Pecten cinctus beds Ancyloceras beds Speetonensis zone	Donington Clay and Tealby Beds	Walpen Sands, etc. Atherfield Clay.
100 feet	Zone of Am. noricus Zone of Am. Astierianus	Wanting . . .	Part of the Wealden Beds.
		Spilsby Sands	
	Unconformity		— Hastings Sands.

This view finds support in the opinion expressed by M. Coquand,[1] that the only part of the Speeton Clay series which can be correlated with the Neocomien of the south of France is the zone of *Am. astierianus*, and that all above it must be referred to the Urgonien and Aptien divisions. The zone of *Am. astierianus* is acknowledged by

[1] Bull. Soc. Geol. de France, 2nd ser. vol. 26, p. 211.

all authorities to be homotaxial with the Hauterivien marls and Spatangus limestones, and the oldest Neocomian rocks which underlie these are not therefore represented in the Yorkshire area. I see no reason however why the zone of *Am. noricus* should be excluded from the Neocomian, since that Ammonite is probably only a variety of *Am. neocomiensis*.

Coming now to the question of general nomenclature, I cannot but think that Prof. Judd's proposal to apply the name Neocomian to the whole Lower Cretaceous series was a very unfortunate one. It would appear that at the time of writing his paper on the Speeton Clay, Prof. Judd was under the impression that this series had a claim to be regarded as a distinct system, both on stratigraphical and palæontological grounds;[1] now if subsequent investigation had confirmed this belief, and had led to the establishment of a Neocomian system distinct from the Cretaceous system, but of equal palæontological importance with the other systems which are recognized in geology, no objection could now be taken. But this is not the case: the thickness of the Neocomien, Urgonien, and Aptien rocks in the south of France appears to be very great (from 1000 to 6000 feet), but the mere thickness of a group of strata does not justify the creation of a new system unless they contain a sufficiently distinct assemblage of fossils, and in this case the fauna is neither so large and varied or so peculiar as to entitle them to be separated from the Cretaceous system: they are regarded by all who have studied them as forming the lower portion of this system, just as the Gault and Chalk form the upper portion of it, and their separation would be no more justifiable than that of the Lias from the Jurassic system.

This being so, the proposal to call the lower series Neocomian ceases to be logically defensible, unless a new name is found either for the Upper Cretaceous series or for the whole system which includes both. Prof. Judd's nomenclature, with the belief he then entertained, was a logical one, but I must maintain that the manner in which it has been subsequently employed is entirely illogical. There is an inclination in certain quarters to adopt the name Neocomian for the lower division, and to limit the application of Cretaceous to the upper division; this plan would certainly secure logical uniformity, but those who suggest it are bound to propose a new name for the system which includes these two divisions, otherwise it would only "make confusion worse confounded." There is really no necessity for any such innovation, or for any alteration of the general scheme of nomenclature to which we are accustomed. The Cambrian and the Carboniferous systems are simply divided into lower and upper series, why therefore should we not be content to treat the Cretaceous system in the same way, and to speak simply of Lower and Upper Cretaceous series?

Further, it must be remembered that the majority of French and Swiss geologists use the term Neocomian in its special application as limited by D'Orbigny, and its employment in any other sense, except

[1] See Quart. Journ. Geol. Soc. vol. xxiv. p. 228.

on the strongest grounds of expediency, is therefore to be deprecated. I am fully aware that Prof. Hébert is one of those who has adopted Prof. Judd's nomenclature, but Prof. Hébert appears to shrink from proposing a new name for the Lower (Neocomian) beds, though he employs D'Orbigny's names for the other groups; consequently he has only succeeded in introducing an element of confusion which did not previously exist in the French nomenclature.

The height of incongruity is reached when, by retaining the name of Wealden for the fresh-water beds and adopting that of Neocomian for all our marine beds, we have a Neocomian overlying the Wealden! and consequently applied to the very beds Marcou and Renevier have so clearly and carefully distinguished from those strata which were originally called Neocomian in Switzerland and the south of France (see ante). I trust that I have now made it clear that to continue the use of *Neocomian*, either as a synonym for Lower Cretaceous or as a substitute for Lower Greensand, would be productive of immense confusion, and would entirely stultify the work of two of the principal authorities upon the beds in question. Neither does it seem desirable to introduce the term *Aptien* into British nomenclature, partly because of the difference of opinion which exists in France as to the relative extension of Aptien and Urgonien, and partly because there is not sufficient continuity between the French and English areas to make any correlation so safe and certain as it is in the case of the Upper Cretaceous groups. The Cretaceous rocks of England are now undergoing revision by the members of the Geological Survey, and the desirability of formulating a new nomenclature will be considered when the work is farther advanced: the merits of the name (*Vectian*) which I have already proposed as a substitute for Lower Greensand will then be discussed; at present I am content to let it remain in abeyance. For my present purpose the local names used for the groups in the Wealden area will serve as a means of comparing the beds of southern England with those of northern and southern France so far as is possible under the circumstances; this is done in the following table:—

South England.	*N.E. France.*	*S.E. France.*
Folkestone and Sandgate Beds.	Sands and Sandstones.	Aptien
Hythe Beds.	Plicatula Clays.	
Atherfield Clay.	The red band.	Rhodanien.
	Freshwater Beds.	Urgonien.
	The Oyster Clays.	
Weald Clay.	Yellow Marl.	
	Spatangus Limestone Sands and Clay.	Upper Neocomien.
Hastings Sands.	(Absent).	Lower Neocomien.

VI.—On the Sequence and Systematic Position of the Cambrian Rocks of Nuneaton.

By Prof. C. Lapworth, LL.D., F.G.S.

In the Geological Magazine for December, 1882,[1] I published a brief note upon the "Discovery of Cambrian Rocks in the

[1] Lapworth, Geol. Mag. 1882, Dec. II. Vol. IX. p. 563.

Neighbourhood of Birmingham," in which evidences were adduced demonstrative of the fact that the oldest sedimentary strata of the Lickey Hills, and of the neighbourhood of the town of Nuneaton, previously referred to the Llandovery and Carboniferous respectively, are, in reality, of Cambrian age. Since that date these Cambrian areas have been in part mapped by the members of the Field Geology Class of the Mason College, and many confirmatory and interesting points of detail have been detected by myself and others. Some of these will be found incorporated in Mr. Jerome Harrison's valuable paper on the "Pre-Carboniferous Floor of the Midlands," published in the Midland Naturalist for 1885.[1] My friend Mr. T. H. Waller, B.Sc., kindly undertook the microscopical examination of the igneous rocks associated with these Cambrian strata, but the results of his observations are as yet unpublished. I hope to treat of the subject as a whole at the forthcoming Meeting of the British Association, but as I have recently had to prepare a general account of the Cambrian rocks of the Midlands for the local "Association Guide Book," I have thought that a summary of my conclusions as there laid down respecting the main fossiliferous area of Nuneaton may be of present interest to other geologists working among these rocks, and may serve as a point of departure for further discussion and investigation.

The largest area of Cambrian rocks in the Midlands is that of Nuneaton and Atherstone in Eastern Warwickshire. It extends from the neighbourhood of Bedworth on the south to a point beyond Merivale Park near Atherstone on the north, a distance of about eight miles, and has a maximum width to the north of the hamlet of Oldbury of about a mile and a quarter. On the eastern margin of the Cambrian area its beds are overlain unconformably by the basement beds of the Keuper Sandstone, around and to the south of the town of Nuneaton. To the north of that town they are generally faulted against the Keuper Marl, but are locally overlapped by some of its basal beds. On the western side the Cambrian rocks are overlain unconformably by the lowest sandstones of the East Warwickshire Coalfield, but there appear evidences of faulting between the two systems in some localities.

The sequence of the rocks of this Cambrian area is as follows:—

A. *Caldecote Volcanic Rocks.*

(1) A thin series of volcanic ashes, beautifully stratified, shown in an old cutting (The Tunnel) a few yards to the north-west of Caldecote Lodge, and forming the lowest rocks exposed in the Nuneaton district.

(2) Quartz-felsite and diabase-porphyrite, seen in an old quarry about a quarter of a mile south-east of Caldecote Lodge. The quartz-felsite is often brecciated in character, and is doubtfully intrusive in the Caldecote ashes. The diabase-porphyrite is subsequent in age to the quartz-felsite, resting upon it, making its way into it in veins and strings, and including fragments of the quartz-felsite caught up in its flow.

[1] Harrison, Midland Naturalist, 1885, vol. viii. pp. 38—69 *et seq.*

B. *Hartshill Quartzite.*—Thick-bedded quartzite, with intercalations of sandy shales. This formation extends from Tuttle Hill to Hartshill, and is exposed in many large quarries. The basement beds of the quartzite contain abundant fragments of the Caldecote volcanic rocks. At Mr. Boon's quarry, between Caldecote Lodge and Tuttle Hill, its lowest zone is laid bare, and is almost wholly made up of this derived volcanic material.

Along a straight line ranging from the Midland Railway Station at Nuneaton to the village of Hartshill, near Atherstone, the highest zone of the quartzite is succeeded by the

C. *Stockingford Shales.*—A thick group of purple, green, grey and black thin-bedded shales, which are separable into two main divisions :—

(1) *Purple and Green Shales (Obolella Beds).*

The lowest zones of this division are stained of a deep purple colour, and were formerly worked for manganese. Higher up the purple shales pass up into green and grey beds, but the red beds re-appear at intervals to the summit of the division. At Marston Jabet, Camp Hill, and in many localities beyond Hartshill, fossils occur, which are, however, limited to very thin seams. The commonest forms may be provisionally referred to:—

Lingulella pygmea, Salter.
Obolella sagittalis, Salter.
Orthis lenticularis, Dalm.
Protospongia fenestrata, Hicks.
Acrotreta socialis, Von Seebach.
Obolella Salteri, Holl.

(2) *Gray shales with bands of intensely black carbonaceous shales (Agnostus Beds).*

These are divisible into two main zones :—

(a) *Zone of Agnostus sociale*, Tullberg.

The characteristic fossil of this band is the well-marked variety of *Agnostus pisiformis* (Linn.), which gives its name to the zone. It has been met with in these beds at Chilvers Coton, Stockingford Cutting, and Oldbury Reservoir.

Another very characteristic fossil in the band is *Beyrichia Angelini*, Barr., a well-known Swedish species. Its associated forms are a species of *Lingulella*, apparently identical with *Lingulella Nicholsoni*, Callaway, and a species of *Obolella*.

(b) *Zone of Sphærophthalmus alatus*, Beck. (?= *Zone of Peltura scarabeoides*, Wahlenberg).

The characteristic fossil of this zone is the well-known Scandinavian species *S. alatus* (*S. humilis*, Phill.), already known from the British Upper Cambrian rocks of North Wales and the Malvern Hills.

It is associated with abundant specimens of an Obolella of the type *Obolella sagittalis*, Salt., but with strongly-marked concentric lines of growth (var. *concentricus*). Species of *Agnostidæ* occur more rarely, together with carbonaceous remains resembling the *Hymenocaris vermicauda* of Salter, etc.

The examples of *Sphærophthalmus* are locally abundant but poorly preserved, head, body-rings, and free cheeks. They are confined,

as in the Malverns, to a single seam which is very difficult of detection.

This zone is the highest band of the Cambrian visible in the Nuneaton District, occurring immediately to the east of the unconformably overlying Carboniferous. Fossils have been obtained from it in the quarries to the south-west of Merivale Park, and in the Stockingford railway cutting.

No recognizable fossils have been met with in the Hartshill quartzite, but those enumerated above from the various zones of the Stockingford shales allow us to assign the Cambrian rocks of Nuneaton to their approximate position in the general succession of Cambrian deposits. These Stockingford shales fall apparently into the same systematic position as the well-known Upper Cambrian shales of the Malvern Hills—representing the grey and black shales which there lie between the *Hollybush Sandstone* below and the *Dictyonema* bed above. *Lingula pygmea* and *Obolella Salteri* occur in the lowest shale zones of the Malvern Hills, *Sphærophthalmus alatus* and *Agnostus pisiformis* are among the characteristic fossils of the black shales above. In other words, the Stockingford beds come into the place of a part of the Lingula Flags of North Wales—possibly ranging to the Upper Dolgelly. With the Scandinavian succession the agreement is even closer; the zones of *Agnostus sociale, Beyrichia Angelini* and *Sphærophthalmus alatus* (= zone of *P. scarabeoides*) occurring in the same order in the Midlands, in Scania and in Norway.

Although the underlying Caldecote Volcanic Group has distinctly afforded the material of which the basement bed of the Hartshill Quartzite is composed, it is doubtful if the systematic break between the Caldecote and Hartshill formations is of great moment. The Caldecote ashes have the same general strike and amount of inclination as the overlying quartzite, and are equally unmetamorphosed.

Both the Stockingford Shales and the Hartshill Quartzite are pierced by intrusive dykes of Pre-Carboniferous diorite. This rock has been already described by Mr. Allport, F.G.S., in a memoir which has become classic in the history of British Petrography.

A preliminary notice of the petrographical characters of the Caldecote igneous rocks by Mr. Waller will be found in the paper which follows the present communication.

VII.—Preliminary Note on the Volcanic and Associated Rocks of the Neighbourhood of Nuneaton.

By Thos. H. Waller, B.A., B.Sc.

THE relations of the various rocks of the district lying to the North and South of Nuneaton have already been discussed by Prof. Lapworth from the data afforded by investigation in the field. He put into my hands many specimens of the different rocks for the purpose of microscopical examination. I have also received specimens from Mr. W. J. Harrison, and have collected some myself. Mr. J. J. H. Teall has also placed at my disposal a number of slides which he has had prepared from material of his own collecting.

From these I have prepared a considerable number of thin sections, and I propose to give here a summary of the chief conclusions at which I have arrived as to the following rocks:—

1. The Ashes.
2. The Quartz-Felsite.
3. The Basic rock which is seen in contact with the Quartz-Felsite.
4. The Quartzite.
5. The Diorite in the latter.

1. *The Ashes* from the "Tunnel" at Caldecote are distinctly bedded, and contain, where they are coarsest, angular grains of quartz and felspar; but in most parts the dust has originally been so fine, and subsequent changes have so much veiled the components, that not much can be made out as to their constitution. A light-coloured specimen from this locality has an appearance and texture very similar to those of a tuff from the Pentland Hills, of which I possess a specimen. It contains a number of rather darker grains, which are not evenly distributed all over, but are gathered up into a sort of network with irregular meshes, the open spaces being nearly free from them.

A few of the felspar grains are much larger than the majority of the fragments of which the rock is made up; one well-defined and pretty perfect crystal measuring about $\frac{1}{20}$ of an inch, another of orthoclase measures $\frac{1}{100}$ of an inch. There are occasional fragments of apparently a fine-grained basalt, and in some of these large felspar crystals are included, showing that the basalt was porphyritic. I have seen no well-defined augite, but a few green patches give rather the impression of an altered pyroxene. The quartz fragments are not very frequent, and the general character of the mass is decidedly basic.

In the coarse conglomerate at the base of the quartzite, blocks of ash are found, and those which I have examined are made up of much larger fragments than the specimens from the Tunnel. The fragments present a considerable variety of aspect; a few of them look like pieces of a very vesicular lava—basic apparently: others are pale green, like some of the Welsh felsites of the Snowdon district, and have the peculiar curdled or damascened appearance which has been often described in these.

2. *The Quartz-Felsite.*—It is only sparingly that specimens occur which have the appearance of typical unaltered quartz-felsites. In them the quartz and felspar occur in large grains and crystals, the ground-mass forming as usual inclusions and indentations in the former. In the ground-mass itself the fluidal texture is very marked, and it shows the usual indeterminate polarization of the felsites.

The felspar is much clouded by products of decomposition, but there is a good deal left which allows the twinning to be made out. Both orthoclase and plagioclase occur; in the latter, frequently with very fine and sharply-distinguished lamellæ.

The greater number of specimens which have a general look of quartz-felsite, seem to me to have much more of the character of a felsite brecciated and recemented with probably but little disturbance.

The quartz grains, instead of having mostly rounded outlines, are in very large proportion angular, and have a very fragmentary look. The felspar grains, on the contrary, are very frequently rounded, and the whole of the crystalline constituents are packed closely together; touching, in the majority of cases, as if they had been loose grains. This peculiarity of aspect naturally varies in different specimens, and in one or two I think I have detected a quartz grain in the act of breaking up. It is of irregular shape, and at one side is covered over with a network of strings of minute fluid cavities, which divide it into roughly polygonal portions; as we pass to the other side of the crystal, however, these become lines of an infiltrated green mineral, and at the extreme edge a few of the polygonal fragments are quite detached, and separated from the main mass by portions of the ill-defined ground-mass which occurs in this particular specimen. Here the alternative lies between considering the fluid cavities as the remaining indications of cracks which originally divided the crystal, or looking upon the strings of cavities as original, and as giving direction to the separation by being planes of weakness. It is rather in favour of the former assumption that the reticulated arrangement of the cavities is, so far as my observation goes, more frequent in the specimens which have the greatest appearance of disturbance. Where the crystalline grains of quartz are indented with intrusions of the ground-mass, there is very frequently a line of cavities following the outline of the indentation. One specimen shows very well the care needful in deciding that an apparent inclusion is not in connection with the exterior. A quartz grain has a row of four roundish apparent inclusions. The plane of the section, however, has fallen *just* within the neck connecting one of these included masses with a little indentation of the margin, so that there is a very faintly visible cloud observable showing the actual connection.

In various places in this rock there are green patches and a few black and brown ones. These are not so sharply defined microscopically as they appear in hand-specimens. In some cases they seem to have their margins indented with a quartz grain, or to inclose a bit of felspar; but occasionally they seem quite free from any but microscopic crystals. The black patches, so far as I have examined them, have the look of green serpentinous alteration products, and some of the browner ones have much the appearance of the neighbouring fine ashes, but others seem more filled with minute lath-shaped crystals, which have much of the character of felspar microliths.

3. *The Dark Basic Rock* which is in contact with the quartz-felsite in one little disused quarry has undergone great alteration—in some parts to the complete obliteration of any original structure, in others the components are very fairly preserved. Close to the junction with the quartz-felsite, and running into it in strings and tongues, the appearances strongly suggest a rock originally glassy, which has been subsequently devitrified, like the glassy base of many felsites. In some specimens the structure is markedly porphyritic; felspar crystals of considerable size occurring in a ground of crystals

apparently of felspar of very small dimensions. In others the crystals of felspar are larger and of more uniform size. Extremely little augite has escaped, but it is curious that those which are preserved show, in addition to the twinning with the orthopinacoid as the plane of composition, which is common, the unusual cleavage parallel with the basal plane described by Mr. Teall as occurring in the prevailing pyroxene of the Whin Sill of the North of England. One section approximately in the plane of the clinopinacoid shows the cleavages forming obtuse angles meeting in the plane of composition; the angles were measured as 66° on one side, and 65° on the other, and the extinctions 40° and 41° from the dividing line. Where the colour of the augite can still be seen, it is very pale.

The larger porphyritically-developed felspars give extinction angles such as indicate one of the more basic plagioclases, probably labradorite. Some yellowish hornblende and a green chloritic or serpentinous mineral are apparently products of alteration.

The manner in which this rock, which seems to agree in characters with Rosenbusch's diabase porphyrite, runs in among the quartz and felspar grains of the quartz-felsite previously mentioned, the presence of detached angular quartz grains in its mass, and the appearance of flow which it has, lead me to believe that it flowed as a lava over a broken disintegrated surface of quartz-felsite or of a bed of sand derived from it.

4. *The Quartzite.*—The quartz sand which has formed the foundation of the quartzite shows in some of the lower beds its derivation from such a rock as the quartz-felsite previously described, by the survival of canals and inclosures of the felsitic ground-mass, and indeed, in the conglomerate, quite at the base, little pebbles of felsite occur along with angular fragments of the fine ashes. In the normal quartzite the grains of primary quartz are well rounded, and contain in many cases a great number of minute fluid cavities. The secondary cementing quartz is much more free from cavities or inclusions of any sort. It is an optical continuity with the primary quartz, so that in polarized light the impression is given of polygonal areas of colour. The appearance is markedly different where, as is quite frequently the case, a grain of felspar, or of felsite, or of the ashes, occurs. On these no quartz is deposited, but they are simply enveloped in that which has crystallized on adjoining grains.

5. *The Diorites* which occur in the quartzite are in an advanced state of alteration, and often not much more than the shapes of the old crystal forms can be made out. Calcite is developed in them to a considerable extent.

In a specimen from Tuttle Hill, collected by Mr. Teall, and kindly lent to me by him, the hornblende is in the form of long and comparatively slender crystals, with frequent cross-divisions. A similar structure occurs in a specimen from Merivale Church, kindly given to me by Mr. W. J. Harrison.

REVIEWS.

I.—Dr. Max Schlosser on the Ungulata.[1]

THE author of this memoir, which aims at giving a complete pedigree of all the Perissodactyla and Artiodactyla, is to be congratulated on the amount of information he has brought together, and the strong thought characterizing the whole of it. The pedigrees are indeed given as though they were certain, but we have no doubt that the author himself would admit that they must be regarded as indications only of the way in which the line of evolution may have advanced, rather than the absolute line itself. The author's American experiences render his observations as to the probable identity of many American and European genera of especial value.

The Condylarthra the author regards as the primitive stock from which both the Perissodactyla and Artiodactyla have originated, and points to *Phenacodus* as being very closely allied to *Hyracotherium*. Instead of the nine or ten families into which the Perissodactyla are usually divided, Dr. Schlosser proposes to reduce the number to four. Thus the Lophiodontidæ gives its type genus to the Tapiridæ, while *Hyracotherium* and its allies, together with the Palæotheriidæ, are included in the Equidæ. That there is very much to be said in favour of the inclusion of the Palæotheriidæ in the latter is perfectly true, since the division between them is but an arbitrary one; and there is an equal transition from the Palæotheriidæ through *Pachynolophus* to *Hyracotherium*. It seems, however, hardly consonant with the usual acceptation of the term to include in one family such widely different forms as *Hyracotherium* and *Equus*, even although the one be the ancestor of the other; and the total separation of the former from *Lophiodon*, to which it seems to us to be more nearly allied than is that genus to *Tapirus*, appears decidedly inadvisable. Dr. Schlosser appears, indeed, to think it necessary that all the members of one line of evolution must be included in a single family; but we would point out to him that since he admits the descent of the *suborder* Perissodactyla from the *suborder* Condylarthra, there is no objection against adopting the same view in the case of *families*, and regarding the Equidæ as descended from the Palæotheriidæ, and the latter from the Lophiodontidæ, which may have also given rise to other groups. The Chalicotheriidæ forms the third family, which is taken to include both the Mesodontidæ and Macraucheniidæ; and we confess we should like more conclusive evidence in favour of this view, as the dentition of the latter appears to indicate affinity with *Palæotherium*. The Rhinocerotidæ includes the true Rhinoceroses, *Hyrachyus* and *Elasmotherium*.

We may here be permitted to express some surprise that while the author so reduces the number of families, he follows the example of Gray in retaining a vast number of genera; and we regret (even if it be only on the lowly ground of pity to the power of memory of average mortals) that he did not follow the excellent example of

[1] "Beiträge zur Kenntniss der Stammesgeschichte der Hufthier, etc.," Morphol. Jahrbuch, vol. xii. pp. 1–136, pls. i.–vi. (1886).

Prof. Flower in including all the recent Rhinoceroses and most of the fossil ones in a single genus, as well as in uniting *Paloplotherium* with *Palæotherium*. We are glad to see the identity admitted of *Orohippus* with *Hyracotherium*, and the suggestion that *Eohippus* may also be the same; but we are surprised at the retention of *Pliolophus* (with which *Orotherium* is coupled) as distinct from *Hyracotherium*. *Mesohippus* and *Miohippus* are rightly shown to be indistinguishable from *Anchitherium*, and *Protohippus* from *Hipparion*. Some confusion appears to exist in the author's mind with regard to *Pachynolophus*, since he separates it widely from the so-called *Propalæotherium*, which Gaudry has shown to be identical. The confusion may be in part accounted for by the retention in *Hyracotherium* of the so-called *H. siderolithicus*, which is really a *Pachynolophus;* but it is difficult to understand what forms Dr. Schlosser regards as the representatives of the latter genus. The genus *Tapirulus*, which has been very generally regarded as an Anoplotheroid, is referred to the Tapiridæ, but we could wish for stronger evidence on the point.

In the Artiodactyla the same "lumping" of families is observable. Thus the author proposes (1) the Anoplotheriidæ, (2) the Dichobunidæ, which is subdivided into the Dichobunidæ proper, the Cænotheriidæ, Xiphodontidæ, Tragulidæ, and Gelocidæ, (3) the Tylopoda, (4) the Oreodontidæ, (5) the Anthracotheriidæ, and (6) the Suidæ. We are not quite clear as to the author's views with regard to the Giraffidæ, Cervidæ, and Bovidæ (which is split into Bovidæ, Antilopidæ, and Ovidæ); but they are all regarded as descendants of the Gelocidæ, and it is apparently intended that they should be considered merely as subdivisions of that subfamily,—a view which will hardly commend itself to the English school of zoology. The comparatively wide separation of *Xiphodon* from *Anoplotherium* is in opposition to the view of Prof. Rütimeyer, which is based on the resemblance presented by the former to the undoubted Anoplotheroid genus *Dacrytherium;* and we are inclined to give more weight to the remarkable resemblance existing between the molar dentition of the three genera and the affinity of their general carpal and tarsal structure, than to the features of carpal and tarsal reductions respectively known as adaptive and inadaptive. *Xiphodon* does, however, undoubtedly show strong indications of affinity with the Cænotheriidæ and the Dichodontidæ (Gelocidæ), and thus indicates a transition from the Anoplotheriidæ to the Tragulidæ. The author adopts the recent view of not separating *Eurytherium* from *Anoplotherium*. *Lophiomeryx*, which was placed by Rütimeyer between *Dichodon* and *Gelocus*, is referred to the Tragulidæ, which also contains *Bachitherium; Lophiomeryx Gaudryi*, we regret to see, has been made the type of another new genus—*Cryptomeryx*. The Anthracotheriidæ are taken to include *Merycopotamus*, and also the bunodont *Elotherium* (*Entelodon*), which is classed by Prof. Flower together with *Cebochœrus* and *Chœropotamus* in the Chœropotamidæ. The Suidæ is taken to comprise the two latter genera, together with the Dicotylidæ, Phacochœridæ and Listriodontidæ, and the peculiar genus

Acotheridum, which, although presenting dental characters allied to *Cebochœrus*, yet in other respects is so like *Dichobunus* that it is difficult to think that it is not nearly allied. Both *Palæochœrus* and *Chœromerus* are retained as distinct from *Hyotherium*.

We venture to think that the plan of taking one very large family like the Dichobunidæ and subdividing it into several subfamilies (all of which have the same termination), and the apparent subdivision of one of these subfamilies into sub-subfamilies is not advisable, and is sure to lead to confusion;[1] and we should have thought it better to rank such subfamilies as families, since it is quite impossible to attempt to make all families or other divisions of precisely the same relative value. That the author himself has not succeeded in this we think is evident, when he sees reason to place *Anthracotherium* and *Chœropotamus* in juxtaposition, while *Cœnotherium* and the closely allied *Dichobunus* are made the types of separate subfamilies; but this is still more glaringly the case if the Dichobunidæ is to include all the Pecora (as a subdivision of the Gelocidæ), and yet not to have higher rank than the Oreodontidæ.

It is, however, hardly to be expected that any two persons can entirely agree on such points, and in concluding this notice we beg to congratulate the learned writer on this decidedly valuable contribution to morphological zoology. R. Lydekker.

II.—Dr. C. Depéret on the Pliocene Vertebrata of France.[2]

THIS memoir will be welcomed by all students of the Pliocene Mammalia of the South of France, as it throws much light on many of the forms imperfectly described many years ago by Croizet and Jobert, and Aymard. The work consists of three parts: 1st, a geological description of the Rouisillon basin; 2nd, a description of the Vertebrates; and, 3rd, a survey of the Pliocene Vertebrates of Europe. In the Pliocene the author includes all the strata from the Norfolk Forest-bed to the Montpellier and Casino beds, and follows the usual French view of classing the Pikermi and Mont Lebéron beds with the Upper Miocene instead of at the base of the Pliocene.[3]

The only new species of Mammal described is *Viverra Pepraxti*, which appears intermediate between *V. civetta* and *Ictitherium*; but there are several interesting forms which may be briefly mentioned. The so-called *Antilope boödon* is referred to *Palæoryx*, while *A. torticornis*, Aymard, which has been shown in an earlier memoir to be

[1] We have already been obliged to quote such subfamilies in the same rank with families.

[2] Théses Présentés à la Faculté des Sciences de Paris, sér. A. No. 67, pp. 1-268, pls. i.–v. (1885). The writer of this notice regrets that the work did not come into his hands in time to incorporate some of its information in the British Museum Catalogues.

[3] In a recent memoir (Bull. Soc. Géol. France, sér. 3, vol. xiii. pp. 287-94 [1886]). Prof. Gaudry defends the former view. Since the learned Professor admits the intercalation of Pliocene marine strata in the Pikermi beds, all his reasons appear to us (be it said with all respect) to present a strong savour of the kind of argument known as "begging the question."

intermediate between *Palæoreas* and *Tragelaphus*, is referred to the latter genus, although classed by M. P. Thomas with the former; the occurrence of these Antelopes allied to those of modern Africa at such a recent epoch is of much interest. *Sus arvernensis* is considered indistinguishable from *S. provincialis*, and closely allied to the existing African *S.* (*P.*) *africanus*. The *Hipparion* is identified with *H. crassum*, Gerv., and regarded as distinct from *H. gracile*; and it is suggested that the Montpellier form may also be the same. The Rhinoceros is referred to *R. megarhinus* (*leptorhinus*), but (apart from the evidence of the imperfect cranium) it appears to us almost certain that the dentition represented on pl. i. belongs rather to *R. etruscus*—the teeth being apparently brachydont, the upper premolars showing the strong horizontal cingulum and the third costa characteristic of that species, and the lower molar also exhibiting the distinctive cingulum at both extremities. Among other interesting forms we may mention *Testudo Perpiniana*, which is as large as *T. elephantina*, and a spine indicating the occurrence of a Siluroid which it is suggested may be allied to *Clarias*.

Almost the only point with which we can find fault is the retention of names like *Machærodus Sainzelli* and *M. pliocænus*, which, if not mere synonyms, are from the want of figures of no possible value. The work, with other memoirs by the same author, will be indispensable to all future students of the Fossil Mammalia of France.

R. Lydekker.

III.—Transactions of the Cumberland and Westmorland Association for the Advancement of Literature and Science. No. X. 1884-85.

FOUR papers of geological interest are contained in this volume. Mr. W. G. Collingwood discourses "On Lake-basins of the neighbourhood of Windermere," observing that those which do not lie in anticlinal or synclinal breaks coincide with faults. He has failed to find any evidence of ice-erosion in the minor lake-basins, although ice may have helped to free them from detritus. Mr. J. Postlethwaite contributes a paper on "Trilobites of the Skiddaw Slates," which is illustrated by four plates. The paper simply deals with the general characters of the specimens and with their localities, but few names being given. Great interest however attaches to them as many of the forms are new. These have been named by the author and Mr. J. G. Goodchild in a paper lately read before the Geologists' Association. Mr. H. W. Schneider communicates an article "On the Hæmatite Iron Mines of Low Furness," from which the total production of pig-iron amounts annually to about 550,000 tons; and Mr. J. D. Kendall replies to a previous paper by Mr. T. V. Holmes "On the Best Locality for Coal beneath the Permian Rocks of North-west Cumberland."

We took occasion when noticing a former Part of these "Transactions" to observe that the plan of the Cumberland Association might well be adopted in other counties, where more than one Natural History Society exists. A very proper rule is to print only those

papers which are *local* and *original*. We regret to learn that on account of this rule, the Whitehaven Scientific Association has severed its connection with the Cumberland Association. Surely unity is strength, and surely there are members of the Whitehaven Association who could aid in the progress of science without departing from the salutary rules framed for the benefit of the many. The multiplication of local "Transactions" is a serious evil.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 26, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:

1. "Further Proofs of the Pre-Cambrian Age of certain Granitoid, Felsitic, and other Rocks in North-western Pembrokeshire." By Henry Hicks, M.D., F.R.S., F.G.S.

In this paper the author gave the results obtained by him during a recent visit to N. W. Pembrokeshire. He stated that he had further examined some of the sections referred to in his previous papers, as well as others not therein mentioned, and that he had obtained many additional facts confirmatory of the views expressed by him in those papers. The Lower Cambrian conglomerates and grits, he said, contained pebbles of nearly all the rocks in that area which he had claimed as of pre-Cambrian age; and the fragments of the granitoid rocks, the felsitic rocks, the hälleflintas, and of the various rocks of the Pebidian series which he had found, showed unmistakably that those rocks had assumed, in all important particulars, their peculiar conditions before the fragments were broken off.

Moreover, he stated that there was abundant evidence to show that the very newest of the pre-Cambrian rocks of the area had been greatly crushed, cleaved, and porcellanized, before any of the Cambrian sediments were deposited; hence he maintained that there was in the area a most marked unconformity at the base of the Cambrian. At Chanter's Seat, near St. David's, he found that the Lower Cambrian grits and conglomerates were, in parts, almost wholly made up of fragments of characteristic varieties of the Granitoid rocks which form the Dimetian ridge near by.

The so-called granite of Brawdy, Hayscastle, and Brimaston, he said, there was good evidence to show, was probably of the age of the Granitoid rocks of St. David's. The mass of so-called granite near Newgale, he stated, was composed of rhyolites and breccias, undoubtedly of pre-Cambrian age.

The Roch Castle and Trefgarn rocks, he stated, could not possibly be intrusive in Cambrian and Silurian strata, but belonged to a series of pre-Cambrian rocks. He referred to the important evidence bearing on the age of these rocks given in a paper communicated to the Society, since his last paper was read, by Messrs. Marr and Roberts. These authors showed that in a quarry near Trefgarn

Bridge a Cambrian conglomerate, overlain by *Olenus*-shales, is to be seen resting on the eroded edges of the Trefgarn series. The author examined this section lately, and obtained from the Conglomerate some very large pebbles of the characteristic rocks called hälleflintas, and of the ash-bands, both of which are found *in situ* in the quarry. He therefore maintained that there was the most ample evidence to show that there was a great group of pre-Cambrian rocks exposed in N.-W. Pembrokeshire, and hence that he had proved conclusively that Dr. Geikie's views in regard to these rocks, as given in his paper and more recently in his text-book, are entirely erroneous.

2. "On some Rock-specimens collected by Dr. Hicks in North-western Pembrokeshire." By Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

The author stated that he had examined microscopically a series of specimens collected by Dr. Hicks, and compared them with those described by Mr. T. Davies, in vol. xl. of the Quarterly Journal, and with some in his own collection. He agreed with Mr. Davies's conclusions in all important matters.

The Chanter's-Seat conglomerate contained many grains of quartz and felspar, curiously like those minerals in the so-called Dimetian, together with numerous small rolled fragments, about a quarter of an inch in diameter, exactly resembling the finer-grained varieties of that rock, besides bits of felsite, similar to some which occur in the St. David's district, quartzite, a quartz-schist, and an argillite.

The rocks *in situ* in the Trefgarn quarry were indurated trachytic ashes, together with the curious flinty rock which was the most typical of the so-called hälleflintas. One of the pebbles from the overlying conglomerate perfectly corresponded with the last-named rock, others appeared to be most probably from an altered trachytic ash, differing only varietally from those *in situ*.

After prolonged examination of this "hälleflinta" of Trefgarn and the similar rocks from Roch, he was of opinion that while it was possible that some specimens might be altered ashes, most of them were originally rhyolites or obsidians, devitrified, and then silicified by the passage of water which had contained silica in solution. The Trefgarn group obviously could not be intrusive in the Lower Cambrian, and it was extremely improbable that the Roch Castle series was newer than the basement conglomerate of that district.

The Brawdy granitoid rock might be a granite, but at any rate it presented considerable resemblance to the "Dimetian."

It was therefore evident that the Cambrian conglomerate of St. David's was formed from a very varied series of rocks, some of them much older than it, and that the Dimetian could not be intrusive in it. Moreover, even if the Dimetian should be proved ultimately to be a granite, and the core of a volcano which had emitted the rhyolites, sufficient time must have elapsed after its consolidation and prior to the making of the conglomerate to remove, by denudation, a great mass of overlying rock. Hence, whatever its nature, it was pre-Cambrian.

3. "On the Glaciation of South Lancashire, Cheshire, and the

Welsh Border." By Aubrey Strahan, Esq., M.A., F.G.S., H.M. Geological Survey. By permission of the Director-General.

Part I. South Lancashire and Cheshire.

The average direction of the large number of glacial striæ which have been observed in the neighbourhood of Liverpool is N. 28° W. Further up the Mersey there is a slight deflection towards the east. Two instances only occur of striæ having a totally different direction, namely E.N.E. The striæ themselves seldom furnish any evidence as to the direction in which the ice travelled, but the edges of the strata have in many cases been bent back from the north-west. The materials of which the drift is composed, both matrix and included boulders, have also travelled from the north-west. The sands and gravels also are arranged in long banks, trailing away from the south-west sides of the rock-hills, in such a way as to show that they were distributed by currents from the north-west. The striæ are found in connexion with the Boulder-clays, in which the actual presence of ice is abundantly proved. Presumably the same agent that distributed the Boulder-clay also striated the rock-surface and moved from the north-west.

Part II. The Welsh Border.

The striations within the Welsh Border also show a general parallelism, but in a direction E.N.E., the few exceptions that occur being close to the Border. The direction in which the drift has been transported shows a corresponding change; though analogous in arrangement to the Lancaster drift, it has all travelled from W.S.W. to E.N.E. The boundary between the northern drift of the English side and the western drift of the Welsh runs approximately along the coast, bending inland here and there, and cutting inland across parts of South Flintshire and Denbighshire. The transportation of the Welsh drift has taken place across the lines of the principal hill-ranges and valleys. Occasionally the two drifts shade one into the other, or are mixed together; but as a general rule the far-travelled northern drift overlies the more local deposit, and is easily distinguishable by its different materials and by its being comparatively stoneless.

It may be concluded that:—

1. The striæ on the English and Welsh sides respectively, while showing variations among themselves, by a marked preponderance in one quarter of the compass, indicate a direction of principal glaciation, this direction being on the English side from about N.N.W., and on the Welsh from about E.S.E.

2. The direction of glaciation in both districts agrees very closely with that of the transportation of the drift, but is only locally influenced by the form of the ground.

3. The striæ are by no means universal, but are found almost exclusively in connexion with those beds in the drift which contain evidence of the actual presence of ice.

Part III. Origin of the Striæ.

The striæ are not such as can have been produced by valley-glaciers; they go across and not down the valleys, nor are there any moraines. The question resolves itself into (1) the hypothesis of two ice-sheets moving in different directions in the two areas; (2) that of floating-ice. The first is opposed by the facts that the rock-surface is not *moutonnéed* on a large scale, and that the striæ and terminal curvature are far from universal; that the drifts associated with the striæ are marine deposits; that striæ having different directions are found on the same slab. The well-known occurrence of gravel-ore in the drift at the outcrop of a vein is also against this hypothesis. The marine origin of the drifts is indicated by their well-marked stratification as a whole, by the alternations of well-washed sands and gravels with the Boulder-clays, and by the occurrence through all the beds of marine shells. A lower or basement-clay is seen in places under this marine drift, but it is always the latter with which the striæ are associated. The great development of undoubted marine beds and comparative rarity of *moutonnéed* surfaces constitute the principal differences between this region and the north, where the existence of an ice-sheet has been strongly advocated. Anglesey is considered by Sir A. Ramsay to have received its configuration by the action of an ice-sheet from the north; but its physical features appear to be due rather to its geological structure, and to have existed in more or less their present form in pre-glacial times.

The arrangement of drifts in this district presents an analogy with that of the Norfolk drifts, and probably results from a similar sequence of events.

The marine drifts, from their great variability, seem to have been distributed, and the striations produced by floating-ice, driven by tidal or oceanic currents, during the time of submergence. During this time Snowdon and the surrounding hills must have stood well above water, forming an island-group, and by such a group the prevailing currents from the north would be deflected to the south-west over Anglesey on the one side, and to the south-east over the plains of Cheshire and Shropshire on the other, while within the limits of the group a local circulation might be maintained.

II.—June 9, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Volcanic Rocks of North-eastern Fife." By James Durham, Esq., F.G.S., with an Appendix by the President.

After describing the general distribution of the volcanic rocks of Old Red Sandstone and Carboniferous age in the counties of Forfar and Fife, the author called attention to a fine section exhibited where the Ochil Hills terminate along the southern shore of the Firth of Tay. In immediate proximity to the Tay Bridge, a series of the later volcanic rocks, consisting of felstones, breccias, and ashy sandstones, are found let down by faults in the midst of the

older porphyrites (altered andesites) which cover so large an area in the district. The breccias contain enormous numbers of blocks of a red dacite (quartz-andesite), and inclosed in this rock angular fragments of a glassy rock, resembling a "pitchstone-porphyry," are found, everywhere, however, more or less converted into a white decomposition-product. The youngest igneous rocks of the district are the bosses and dykes of melaphyre (altered basalt and dolerite), which have been often so far removed by weathering as to leave open fissures.

In the Appendix three very interesting rocks were described in detail. The rock of the Northfield Quarry, which is shown to be an augite-andesite, has a large quantity of a glassy base with felted microlites, and contains large porphyritic crystals of a colourless augite. The rock of the Causewayhead Quarries is described as an enstatite-andesite; it has but little glassy base, being made up of lath-shaped felspar crystals (andesine), with prismatic crystals and grains of a slightly ferriferous enstatite; there are no porphyritic crystals, but the enstatite individuals are sometimes curiously aggregated. The red porphyritic rock from the breccias near the Tay Bridge was shown to be a mica-dacite, and the glassy rock associated with it to be the same material with a vitreous in place of a stony base. This glassy base exhibits very beautiful fluidal and perlitic structures. The crystals of first consolidation in this rock are oligoclase and biotite, often showing marks of injury in transport; those of the second consolidation appear to be orthoclase. In conclusion, the successive stages by which the andesitic rocks of the area were altered, so as to assume the characters distinctive of porphyrites, were fully discussed, as well as the change of the glassy rock into its white decomposition-product.

2. "On some Eruptive Rocks from the Neighbourhood of St. Minver, Cornwall." By Frank Rutley, Esq., F.G.S.

The rocks described in this paper were derived from Cant Hill, opposite Padstow, and from a small quarry about half a mile from Cant Hill, near Carlion. At the former locality the volcanic rocks are much decomposed, but from their microscopic characters they may be regarded as altered glassy lavas of a more or less basic type. No unaltered pyroxene, amphibole, or olivine is to be detected in the specimens described, but there is a considerable amount of secondary matter which may include kaolin, serpentine, chlorite, palagonitic substances, etc. There is evidence of fluxion-structure in some of the sections; others are vesicular, and the vesicles are usually filled with siliceous or serpentinous matter. The relation of these lavas to the underlying Devonian slates was not ascertained. The rock occurring near Carlion contains numerous porphyritic crystals of augite, in which the crystallization is interrupted by the co-development of small felspar crystals, which appear, as a rule, to have been converted into felsitic matter. Ilmenite is also present in patches which indicate a similar interrupted crystallization to that shown by the augite. The rock has the mineral constitution of an augite-andesite; but since it is a holocrystalline rock, exception would be

taken by many petrologists to the employment of the term andesite. The lavas of Cant Hill were also probably of an andesitic character, so that, so far as original mineral constitution is concerned, there is some apparent justification for the mapping of both of these rocks as "greenstone" by the Geological Survey.

3. "The Bagshot Beds of the London Basin." By H. W. Monckton, Esq., F.G.S., and R. S. Herries, Esq., B.A., F.G.S.

The authors stated that their object was to describe more fully the Lower Bagshot beds, and to disprove the view lately advanced by Mr. Irving that, in certain places, the Upper Bagshots overlap the Lower and rest directly on the London Clay. They described or referred to a number of sections all round the main mass, beginning at St. Ann's Hill, Chertsey, where they considered that the mass of pebbles and associated greensands must be referred to the Middle Bagshot. The outliers near Bracknell and Wokingham were shown to consist of Lower and not Middle Bagshot, which does not appear in the valley north of Wellington College.

The Aldershot district was explained, and it was shown that the beds there resting on the London Clay were Lower and not Middle Bagshot, and the occurrence of fossils in the Upper Bagshot of that district was recorded.

The conclusions that the authors came to were, that a well-marked pebble-bed was almost always present, marking the division between the Upper and Middle Bagshots, but that there were other pebble-beds of a less persistent character occurring both in the Middle and Lower Bagshot; that the Lower Bagshots generally consist of false-bedded sands with clay laminæ and no fossils except wood, whereas the Upper Bagshots are rarely false-bedded, and are characterized by the absence of clay bands and the presence of marine fossils; and that the Middle Bagshot is a well-marked series consisting of green sands and clays.

They claimed, in conclusion, that there was no reason for disturbing the old reading of the district, and that there was no evidence of an overlap of the Lower Bagshots by the Upper.

CORRESPONDENCE.

SLICKENSIDED SURFACES OF CHALK.

Sir,—Mr. H. Hutchins French, F.G.S., and I have discovered widely spread surfaces of chalk slickensided horizontally in the neighbourhood of Sutton, Surrey. There seems to be abundant evidence that these markings are really due to friction, and they are associated with a remarkable cleaved structure at a high angle to the bedding. This cleavage is very striking, and we should be glad to receive any notices of similar phenomena in the Chalk.

We also find the Thanet Sand to extend further west than was supposed to be the case, it being some 15 feet at Leatherhead, where